SOME ASPECTS OF THE DEVELOPMENT OF REASONING IN PRE-SCHOOL CHILDREN

BARBARA A. WALLINGTON

PH.D

UNIVERSITY OF EDINBURGH

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I hereby certify that the research and analysis thereof described in this thesis was my own work, and that I have written this thesis myself without assistance.

Barbara A. Wallington

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SUMMARY

In this study an attempt has been made to examine the behaviour of pre-school children in reasoning tasks. The tasks have been made as simple as possible on the assumption that many reasoning experiments with young children fail to elicit evidence of reasoning behaviour, not because the child is incapable of reasoning but, because the complexities of the task and the variables extraneous to reasoning involved inhibit its appearance. Adult subjects have also been tested on the same tasks as the children in order to gain a 'standard' against which the children's performance might be measured.

Of particular interest in this study has been whether pre-school children can act strictly in accordance with verbally presented information fully accepting its constraints and whether they can make inferences defined as the drawing of a conclusion which follows necessarily from, but is not explicitly contained within, information given to the children.

Seven experiments were conducted (six of which afforded the opportunity to demonstrate inferential behaviour). From the results it was found that insofar as the verbally presented information conveyed the nature of the task, then all the pre-school children acted strictly within its limits. For example when the verbally presented information stated that a particular type of verbal response was required (e.g. a judgement of 'all right' or 'wrong') this type of verbal response was given. Where

the verbally presented information was that presented within a premiss then some of the children in some of the tasks acted strictly in accordance with it and it is argued that these children demonstrated the ability to make inferences. These children produced responses which appeared equivalent to adult responses.

The children who did not make inferences, however, did not behave randomly. They acted strictly in accordance with the nature of the task and produced task appropriate behaviour, i.e. they did not produce behaviour which conflicted with the type of verbal and nonverbal activity which the task required. They responded consistently either with systematic search or systematic repetitive strategies which were independent of the information within the premiss, or with consistent adherence to part of the information contained within the premiss.

CONTENTS

CHAPTER I

INTRODUCTION

A. Area and Aims of Study

The reasoning processes of pre-school children (three to five year olds) have received only limited attention from psychologists. Inadequate testing techniques, the restricted availability of subjects of this age and our comparative ignorance of relevant related issues, such as linguistic, social and emotional development, have probably contributed to the scarcity of information. In addition those studies which have been carried out conclude, in the main, that the pre-school child does not possess reasoning ability.[1] Thus, on available evidence, the area would appear to have little to offer to the experimental psychologist interested in reasoning processes.

The present writer, however, argues that this is not the case and that non-experimental observations of pre-school children indicate that this area, far from being infertile, is one of rapid and frequently dramatic reasoning development. In support of this view, Donaldson (1970) says: 'observations of the "spontaneous" behaviour of children considerably younger than this (seven years) can yield instances of what appear to be complicated inferential acts'. She goes on to describe a recorded example of such an instance, which took place between a research worker and a child just over five soon after the death of

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1. A review of relevant literature is given in Section B of this chapter.

Donald Campbell. Another research worker named Mr. Campbell had tested the child on earlier occasions. The child asked: 'Is that Mr. Campbell who came here ... dead?' When she was assured that Mr. Campbell was not dead, she responded with: 'Well, there must be two Mr. Campbells then, because Mr. Campbell's dead, under the water.' It is difficult to describe this as anything other than a demonstration of reasoning.

It is evidence such as this which suggests that we may be making gross underestimations of the pre-school child's reasoning ability and that this ability is worthy of study, not only in its own right but also, as part of the development of reasoning in human beings generally. Moreover the task for psychologists is not to deny the existence of reasoning in young children because it is non-testable by conventional means, but to concentrate on ways and means of making such behaviour more accessible to systematic study.

This is a task of no small magnitude. Our current knowledge of child testing techniques is largely unformulated. To a great extent testing children is carried out on a trial and error basis backed by only limited theory. The fact that a child fails to demonstrate a particular type of response in a test can by no means be taken to imply that he is not capable of such a response. It is just as reasonable to assume that the test was not capable of eliciting the response.

One of the aims of this study is to design techniques which are capable of drawing out reasoning behaviour in

young children. Non-experimental observations suggest that reasoning in some situations is available to these children, but the majority of earlier experimental observations have concluded that such ability is lacking. In some ways the task of finding adequate techniques is rather like looking for the proverbial needle in the haystack.

Nevertheless, there is an assumption from which one can start. This is the assumption that much of the earlier experimental work on children's reasoning has been confounded by variables extraneous to reasoning per se and that the complexities of the test situations, in many experiments, have themselves been sufficient to result in a failure to elicit, or have inhibited, reasoning behaviour.

What are these confounding variables which are assumed to influence experimental findings? Some we are aware of, others we cannot identify; some we can specify and isolate, others we cannot; some apply to experimentation with adults and children, others are peculiar to the child testing situation; some we can reduce or control and others are not amenable to such procedures. Further some variables are extraneous to reasoning whereas others are part of reasoning itself.

Amongst those variables which influence experimentation are culture differences. For example, Sigel and Mermelstein (1965) found that Negro children from Virginia who did not attend school were unable to solve class-inclusion problems normally solved by Western children attending school. Greenfield (1966) found that African Bush children and French-educated children gave different

conservation explanations.

Personality is another variable which plays a part. Kagan, Moss and Sigel (1963) have identified three personality-related cognitive styles used over a variety of tasks. Wallach and Kagan (1965) have demonstrated that modes of classification are related to personality characteristics and Kagan, Pearson and Welch (1966) suggest that the impulse-control dimension will result in different performances between children who are impulsive and respond quickly without reflection and those who are controlled and respond more slowly and carefully.

Much of the variation in experimental results can also be attributed to the subject's pre-experimental experience. With children the amount and nature of play activities can be important. Charlesworth (1964) says that the child may experience cognitive conflict when he meets unexpected situations in his play and this conflict will encourage a reordering of cognitive structure. Manipulation of various materials such as clay and water provides feedback which could facilitate the acquisition of conservation. (Metcalf, 1965; Sigel and Mermelstein, 1965; Sigel and McBane, 1967).

Other variables are related quite closely to the task the subject is required to perform. Lack of intrinsic interest may account for young children failing to perform some conservation tasks (Inhelder, 1962). Task complexity may lead to similar failures. This complexity can take a variety of forms ranging from a simple increase in the number of objects the child has to manipulate or make

judgements on to the number of different transformations and operations within a task. Feigenbaum (1963) found in a conservation of quantity task that using twenty-eight beads and using fourteen beads produced no difference in children's ability to conserve, but when he rearranged the beads into seven pairs of two beads and fourteen pairs of two beads the latter arrangement resulted in failure of conservation in some children. The number of transformations which material in continuous quantity studies undergoes before the child makes a response also affects the failure rate (Smedslund, 1966a).

The language used in experimental situations is pointed to as a source of considerable variation in experimental results, particularly with children and particularly in relation to traditional Piagetian studies. It is argued that the language used by the experimenter and that used by the child do not always have a common 'meaning' with the result that a child fails to perform a task, not because he lacks the ability to do so, but because he never appreciates what he is being asked to do and moreover, when the child has to give a verbal response, the experimenter does not necessarily understand the 'meaning' behind the response. Flavell (1963) says of Piaget: '...much of the criticism of Piaget, especially the early Piaget, comes down to a dissatisfaction with his language-thought translations'.

As a consequence of such criticism studies have evolved which attempt to reduce or change the linguistic component of cognitive tasks. Braine (1959) utilized a nonverbal technique and claims that such a technique elicits tran-

sitivity of length two years earlier than the age at which Piagetian procedures elicit length transitivity. Cohen (1967) had similar findings with conservation when she eliminated such ambiguous terms as 'same' from her instructions, replacing them with words such as 'share' and 'fair'.[1]

Many expressions used in instructions to the child and which are crucial to the task have been criticized on the grounds of ambiguity and inconsistency in 'meaning' between child and adult. Such words as 'same', 'different', 'bigger', 'longer', 'more' and 'less' fall into this category. Such expressions are open to both a phenomenal interpretation, i.e. 'looks the same', 'looks different', etc. or a reality interpretation, i.e. 'is really the same', 'is really different', etc. Zimiles (1963) says that the child may respond in terms of whichever of these dimensions is stressed by the experimenter's manipulations. Braine and Shanks (1965a) say that until at least seven or eight children spontaneously interpret questions about size as questions about phenomenal size, but they found that the ability to respond on a 'reality' basis began around the age of three and was generally available to all children by the age of five provided feedback information encouraged a 'reality' interpretation. A later study, Braine and Shanks (1965b), indicated that this was also true of shape and suggested it was generalizeable to other attributes;

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1. Further discussion of Braine (1959) and Cohen (1967) will be found in Section B of this chapter.

However, ambiguity is not the only problem which these crucial expressions raise. It has been found that words such as 'less' and 'different' are handled by pre-school children in a way which indicates that they convey directly opposed 'meanings' for children and adults. Instructions containing these 'negative-pole' words are responded to in exactly the same way as their 'positive-pole' counterparts, i.e. 'more' and 'same' (Donaldson and Balfour, 1968; Donaldson and Wales, 1969a).

Failure to remember initial instructions or premisses when making a response has also been put forward as an explanation for failure in some tasks (Fraisse and Vautrey, 1952; Cowan, 1964). Bryant (1971) and Bryant and Trabaso (1971) claim to have demonstrated that children of four can produce correct transitivity of length responses 'provided they can remember the items of information which they are required to combine'.[1]

Finally the scoring criteria used by experimenters are a further source of variation. Piaget, for example, typically requires that a child should verbally justify his response. Others, for example Bruner (1964), do not require anything of the child beyond his response. Gruen (1966) in discussing scoring criteria in conservation says the choice of criteria is not arbitrary, but reflects the 'psychological processes that one assumes underlie conservation'. Consequently 'investigators should be careful to specify what they mean by "conservation"'.

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1. A more detailed account of memory as a confounding variable is given in Section B of this chapter.

It can be seen from the above examples that there are numerous confounding variables which can influence experimentation with children. In the present study an attempt has been made to control and reduce these variables wherever possible in the hope that this will facilitate the emergence of reasoning behaviour in pre-school children. In designing tasks the aim has been to keep the questions asked and problems raised as free as possible from confounding variables of the type mentioned above. This has been done within the limitations of existing test techniques and knowledge and when possible by adapting and introducing techniques which may be conducive to eliciting reasoning behaviour in children of this age.

In part then the tasks have been designed with an awareness of some possible pitfalls, but in part there is also a trial and error element. Because of the gaps in our knowledge of testing children much of the experimental design has to be based on the experimenter's unformulated knowledge and experience of working with children of this age. Therefore the presence or absence of reasoning ability by the children in these experiments has to be judged with this in mind.

The objective in this study has always been to present tasks in the simplest form possible by eliminating all but the essential aspects of the task. But straightforward as some of the issues involved may appear at first, it will soon become apparent that, even at a level as basic as that proposed here, the complexities of the tasks are considerable. Not only are the child's thinking

processes intricate and involved, but the test techniques, material used and language in which instructions are couched, all of which appear simple and straightforward to adults and which are necessary if testing of any form is to take place, are the source of additional complexities with children of this age and can make interpretation of results difficult.

It has often, therefore, been necessary to look at issues which may appear only indirectly relevant to the main theme of the study, but when one considers that testing takes place within a context of test methods, language and physically present material and cannot proceed in the absence of such a context then the context becomes an integral part of the thinking processes under study and has to be considered and assessed as such.

The Nature of inference

We come now to one of the central themes around which this study is based. This is the question of inferential behaviour and the ability or otherwise of pre-school children to make inferences. The use of the word 'inference' calls for some comment and definition since its meaning appears to vary widely from the making of an approximate estimation based on partial knowledge of a situation (Hecox and Hagan, 1971), to 'The independent assertion of a new proposition which is implied by previously asserted ones' (Langer, 1953), to '...an inference is a procedure and not a statement. This procedure can be described only in a rule, formulated in the metalanguage, and symbolically

expressed by a schema' (Reichenbach, 1947).

For the purposes of this study a child is considered to have made an inference when he draws a conclusion which follows necessarily from, but is not explicitly contained within, information given to him.

In this study the information is presented in a verbal/visual combination or verbally alone. In the cases where the information is presented in a verbal/visual combination the child is required to act upon concretely present material and/or make a verbal response. In the cases of the verbally presented information no concrete material is present and the child is required to give a verbal response.

Oléron (1969) distinguishes three forms of inference or reasoning which he says to a certain extent correspond to three levels. The first form he describes as 'actually experienced inferences'. These occur when 'the subject simply puts into operation response schemata which have already been constituted and which establish a connection between a given category of stimuli and gestures or actions which the stimuli could not spontaneously have produced'. The second form is 'material reasonings'. 'These draw on a symbolism which is usually verbal but which may be made up of representations of an even more concrete nature. The way in which they unfold is determined by content, that is, by the objects to which the symbols refer and by the connections between them, as revealed by experience.' Oléron says that almost every inference which a man uses is of this type, that it is found in pre-scientific thought

and that it often reveals faulty chains of thought. The third form he names 'formal reasonings'. He says: 'These also have a symbolic basis, which may be verbal or specialized (symbols used by mathematicians and logicians). Chains and combinations of proposition proceed vi formae, i.e. they are not a mere reproduction of empirical connections. They obey rules defined within the system concerned.'

It is Oléron's third form of inference with which this study is primarily concerned although the second form does play a part both directly and indirectly.

A useful way of looking at the issues involved in this study is through Von Wright's (1951) discussion of modal logic. The necessity which links the conclusion with the information given to the subject is a concept falling within his alethic domain of modal logic. Von Wright distinguishes between a number of modal categories, two of which, the alethic and the epistemic, are relevant to the present study. The alethic and epistemic domains respectively correspond quite closely with Oléron's 'formal reasonings' and 'material reasonings'.

For Von Wright the alethic modes (or modes of truth) are concerned with what is true, what is not true and what may be true whilst the epistemic modes (or modes of knowing) cover what is known to be true, what is known to be not true and what is neither known to be true nor known to be false. Schematically they can be displayed as in Figure 1.

In the alethic modes possibility is given by Von Wright as the 'only undefined modality we need'. From

Figure 1
Alethic and Epistemic Modes

Alethic	Epistemic
Necessary	Verified
Possible	——
Contingent	Undecided
Impossible	Falsified

this he goes on to define necessity, contingency and impossibility as follows: 'If a proposition is not possible, it is called impossible. If the negation of a proposition is impossible, the proposition is called necessary. If a proposition and its negation are both possible, the proposition is called contingent.' It will be seen from this that the concepts of necessity and contingency are narrower than that of possibility so that all necessary propositions are possible as are all contingent propositions, but not all possible propositions are necessary nor are all possible propositions contingent.

As an undefined epistemic modality Von Wright gives the concept 'known to be true' (or 'verified'). From this he says: 'If the negation of a proposition is verified, the proposition is called falsified. If neither a proposition nor its negation is verified (falsified) the proposition is called undecided.'

It is interesting to note that there is no epistemic term which corresponds with the alethic 'possibility', i.e. there is no word to cover both the 'verified' and the 'undecided'. As Von Wright points out 'possible' is

sometimes used epistemically to mean 'not known to be false', but such use is rare, its more common epistemic use being as a synonym for 'undecided', i.e. 'neither known to be true nor known to be false'.

In this study we are concerned basically with concepts of the alethic variety but, largely as a function of the nature of the experimental situations, epistemic concepts impinge upon the study. For example, a typical kind of experiment used in this study involves the subject, with the aid of an alethic proposition, locating an object in one of a group of boxes. Until he actually locates a box, opens it and sees whether or not the sought-for object is contained within he is, strictly speaking, working within the alethic domain (this by no means implies that this is in fact what he is doing and, as will be seen, he may well be utilizing rules and strategies external to the given proposition), but once he has opened the box the situation changes. He still has available to him the alethic propositions but, in addition, he has the epistemic concepts of verification and falsification. He now knows whether the box contains the object or not.

If one examines further the properties of alethic propositions and considers the features which are peculiar to such propositions, then a number of points which are relevant to inferential behaviour, as defined above, are worthy of note.

The drawing of a necessarily true conclusion from a premiss without the utilization of any other external data is analytic. Ayer (1964) holds that: 'a proposition

is analytic if it is true solely in virtue of the meaning of its constituent symbols, and cannot therefore be either confirmed or refuted by any fact of experience'. Kant in 'Critique of Pure Reason' defines analytic propositions in a similar vein: 'the predicate B belongs to the subject A, as something which is covertly contained in this concept A'. He describes analytic propositions further as 'adding nothing through the predicate to the concept of the subject, but merely breaking it up into those constituent concepts that have all along been thought in it; although confusedly'. Such a proposition then is demonstrative in the sense that its 'premisses necessitate its conclusion', i.e. it is necessarily truth-preserving, and nonampliative in the sense that the conclusion says 'nothing that was not already stated in the premisses' (Salmon, 1967).

Requirements of the subject

We can now ask what is required of a subject if he is to demonstrate inferential behaviour. What are the conditions he must satisfy?

As Donaldson (1971) says: 'A fundamental requirement for any system that is capable of inferential activity is that it should be able to operate in terms of relationships of compatibility and incompatibility. That is, it has to be capable of making decisions about whether the co-occurrence of given states of affairs is possible.' In addition, in making inferences, a subject has to be capable of extending his decision-making beyond compatibility to necessity so that he can decide that a conclusion

is not only compatible with a premiss, i.e. possible, but also necessary. Furthermore, he is required to restrict himself to the bounds of the premiss and draw conclusions on an analytic basis only.

Other requirements of the subject are perhaps more a result of the conditions necessary for obtaining systematic information on the child's reasoning than requirements of inferential behaviour. For example, the child is required to submit himself to the confines of a formal experimental situation. Formal situation here is used in the sense of a situation which the child himself does not initiate, a situation which is not spontaneous.

Moreover, he is also required to act in accordance with verbally presented information. Sheldon White (1969) raises this when discussing cognitive changes in children between the ages of five and seven. He says that after the age of five there is a bidirectional improvement in the 'ability to sustain a proposition to guide successive behaviour segments' and in the 'ability to integrate successive behaviour segments to form a proposition.'. Along with this improvement there is also an increase in speed of inner reaction, i.e. an increase in the speed of 'locating recognition, meaning and association to an event'. From this he suggests that changes in reasoning ability may come about because more 'bits' of information can be processed by the child in a given length of time. This suggests that when testing young children, the information presented to them should be neither complex nor lengthy and in describing the conditions and precautions for testing children White says: 'One never gives lengthy

verbal instructions. The shorter the instructions, the better.' The present study endeavours to adhere to a policy of brevity and noncomplexity in verbal instructions.

The Russian psychologists, particularly Luria and his associates, are concerned with the role of language in the regulation of behaviour and with the ability of young children to voluntarily regulate their behaviour in accordance with verbal instruction. Their work has its roots in Pavlov's second signalling system and the problems raised by Vygotsky (1962) concerning the functions of speech as it passes from overt to covert forms. Luria (1961a) says: 'In Soviet psychology it has been established that voluntary activity does not originate from any primordial properties of an internal life, but from the relations between a child and an adult. The adult at first describes certain tasks to the child, who is later able to carry them out in response to his own verbal instructions.' Soviet psychologists then are interested 'both in the ways in which speech of adults can direct the behaviour of children, and in the ways in which children can influence their own behaviour by speaking.' (O'Connor, 1966).

Luria (1959) distinguishes four functions which the verbal instructions of an experimenter can have. Firstly there is an orienting function, secondly an initiating function, thirdly an inhibiting function and fourthly a regulatory function. The child acquires these functions in the above order.

During the first six months of life if a child is asked to hand an object to the experimenter there is

unlikely to be a response. After six months the child may look at the experimenter and around twelve months at the object. The orientation function of speech is thus established. Around eighteen months the initiating function begins to appear. A child responds to simple instructions such as 'Clap hands', but only if the required behaviour does not conflict with the child's ongoing activities. Luria (1961b) says: 'Try giving a child of twenty months to two years verbal instructions to take its stockings off while it is pulling them on.' At this stage then an adult's speech cannot yet inhibit an action once started, nor can it switch the child from one action to another.

The regulatory function of language does not appear until later, the age of acquisition depending on task complexity. One of Luria's tasks required the child to press a bulb when a light came on. At the age of two-and-a-half the child presses the bulb as soon as he hears the word 'press' and before the light comes on. When the light does appear it acts as an 'external inhibitory agent' causing the child to discontinue pressing. A year later the child can carry out the instruction correctly demonstrating the appearance of the 'regulatory function proper'. However, if a child of this age is instructed to press the bulb twice when the light comes on he presses it three, four and many times in succession even if he is aware of the meaning of 'twice'. It is not until the age of four-and-a-half to five-and-a-half, when the regulatory function begins to move from the external to

the internal speech of the child, that a more stable system of motor reactions to verbal instructions occurs and even then task complexity can prevent success.

According to Luria's position then, the children in the present study are at a critical stage in their development where the regulatory function of language is unstable.

Apart from the distinction drawn above (p. 15) between formal and spontaneous situations, one can perhaps also talk about degrees of formality or the extent to which the constraints of the test situation are removed from the ordinary experiences of the child's everyday life and the extent to which other constraints, in addition to verbal ones and other than those basic to the task, impinge upon the test situation. It is by no means improbable that such test constraints are sufficient to inhibit the appearance of behaviour of which the child is capable in a more conducive context.

It may well be that the child's difficulty in confining himself to a formal situation, his difficulty in restricting himself to verbally presented information and the additional complexities of test constraints go at least part of the way towards explaining why most experimental attempts to demonstrate inferential behaviour in young children have met with a marked lack of success. Therefore, if experimental tasks are made extremely 'simple' and the level of test constraint reduced as far as possible, some evidence of inferential behaviour may appear or at least some indication may be gained of the types of behaviour young children produce in reasoning tasks.

Summary of aims of study

Briefly then the questions which this study asks and attempts to answer via simple experimental situations are:

1. Are pre-school children capable of acting strictly in accordance with verbally presented information?
2. Are pre-school children capable of drawing necessary conclusions from premisses in which the conclusion is implied, but not explicitly stated, i.e. are they capable of making inferences?
3. If pre-school children cannot make inferences, do they make any kind of response in the experimental situation and, if so, on what is it based?

B. A review of Relevant Literature

The work of Piaget and the Geneva school is foremost and best known in its denial of the ability to operate at even a level approaching inference before the age of seven or eight. Prior to that age the child passes through a pre-operational stage in which his thinking is egocentric with respect to representation (Piaget, 1955). Another level of egocentricity occurs during the earlier sensori-motor stage when the child is unable to distinguish his actions from their environmental consequences. The ability to make this distinction begins during the second year of life, but there still remains 'the problem of mentally representing what has already been absorbed at the level of action' (Piaget and Inhelder, 1969).

The representational egocentricity of the pre-operational child is revealed in his inability to see his own view-point as one of many. For example at four or five a child may be able to distinguish his own left hand from his right hand, but it is not until much later that he appre-ciates that the hand to the right of a person facing him is that person's left hand. In a similar vein the pre-operational child when talking to a person does not adapt his speech to the needs of the listener (Piaget, 1926).

Another way in which Piaget talks of egocentrism is through the concepts of centration and decentration. The pre-operational child tends to 'center' on one particular attribute of a situation at the expense of other relevant attributes. He is unable to 'decenter' from this one attribute thus failing to notice attributes which compensate

for the distortions of this single centration (Piaget, 1950; Piaget, 1953). For example, in conservation tasks he will take account of only one dimension of the array, such as the height of liquid in a beaker or the length of a row of discrete objects, ignoring the dimensions of the width of the glass and the density of the discrete objects (Piaget, 1952).

The child's pre-operational thought operates with static images of reality, by isomorphic, step-by-step replicas of actions and events, rather than by reordering events as does the older child. Things are what they appear to be in immediate, egocentric perception. This characteristic of pre-operational thought Piaget terms 'realism'(Piaget, 1951a; Piaget, 1951b). When the child considers static situations, he explains them in terms of the characteristics of their configuration at a given moment rather than in terms of changes leading from one situation to another i.e. in terms of transformations (Inhelder and Piaget, 1958). Moreover, there is a relative absence of stable equilibrium between assimilation and accomodation such that 'the child is unable to accomodate to the new by assimilating it to the old in a coherent, rational way, a way which manages to preserve intact the fundamental aspects of the previous assimilatory organization. Thus ... he is the slave rather than the master of changes in ...configuration; the successive changes pull him this way and that way, draw him into flagrant contradictions with earlier cognitions, and in general destroy any momentary assimilation-accomodation equilibrium

he may have attained just previously.' (Flavell, 1963).

Finally pre-operational thought is irreversible. It cannot compose into a single organised system the various compensating changes resulting from transformations. Two kinds of reversible transformations, which appear at the level of concrete operations (seven to eight years), but are absent at the pre-operational level, are postulated by the Geneva school. Firstly there is inversion where +A is reversed by -A. For example the transformation of dividing a ball of plasticine into two smaller balls can be reversed so that the two small balls make the original single ball. Secondly there is reciprocity where A<B is reciprocated by B<A. For example the height of water in a wide glass A is less than that in a narrow glass B, but this is compensated for by the width of glass B being less than that of glass A. (Inhelder and Piaget, 1958; Piaget and Inhelder, 1969; Piaget, 1970).

It is these features of pre-operational thought, egocentrism, centration, realism, unstable equilibrium between assimilation and accomodation and irreversibility, which, according to Piaget, preclude the pre-school child from making inferences. Thus, lacking the necessary thought structures, he centers on one dimension of an event and proceeds irreversibly to draw a conclusion from it based on some other perceptually compelling happening rather than appealing to logical necessity. (Flavell, 1963).

Piaget's theory has provided the impetus for a substantial proportion of the studies of children's reasoning, not only in Geneva, but throughout the world. But whether

they have been validation studies (e.g. Peel, 1959; Dodwell, 1960; Elkind, 1964) or learning studies (e.g. Wohlwill and Lowe, 1962; Smedslund, 1961) they have been, in the main, supportive of Piaget's theory.

However, there has always been an undercurrent of criticism which validation and learning studies, such as those mentioned above, have not quelled. As early as 1930 Hazlitt said: 'Piaget's picture of a striking difference between adult and childish thinking is, I believe, due to an over-valuation of verbal expression as a measure of thinking.' Much later Berko and Brown (1960) say: 'Piaget is inclined to see through words as though they were not there and to imagine that he directly studies the child's mind. In fact, he is often concerned with the comprehension of utterances.' Dienes (1965) describes an experiment conducted by Gréco in which five year old children put beads, one at a time, into two differently shaped receptacles. Even after the number of beads in the receptacles exceeded the numbers for which the children knew the number names, the children would still insist that the contents of the two receptacles were equal because each time they had put a bead in one, they had also put a bead in the other and there must be the same in each. Dienes contrasts this result with Piaget's findings and like Hazlitt and Berko and Brown above, draws similar conclusions: '.....some of the conservation responses in the experiments conducted in Geneva might have been due to a misunderstanding on the part of the children, that is, the vocabulary used by the child might not have had the

same semantic significance as the vocabulary used by the experimenter. When the child says "the same", he might well mean "looking the same" or "having the same height" ... It is possible that children in these experiments were simply speaking a different language and thinking different things and yet using the same words'.

Piaget has not been unaware of the difficulties of communicating with children. He says: ' ...the effort ... to communicate one's thought objectively does not appear in children before the age of about 7 or 7½' (Piaget, 1926). The solution he offers is to observe and use children's spontaneous questions. 'We may thus state the first rule of our method. When a particular group of explanations by children is to be investigated, the questions we shall ask them will be determined in matter and in form, by the spontaneous questions actually asked by children of the same age or younger'(Piaget, 1951b). But, as Flavell (1963) says: 'He has not, however, always followed his own stated precautions regarding it, and has frequently made cognitive inferences from verbal protocols as though there were no translation problem at all.'

Two studies aimed at overcoming the language barrier in Piagetian experiments (Braine, 1959; Cohen, 1967) have already been mentioned briefly (p. 5) but will be considered now in more detail. Braine designed a largely nonverbal test in order to assess the presence or absence of length transitivity in children between the ages of three years six months and seven years. The first stage of the experiment consisted of a training procedure in which the child

had to lift the longer (or shorter) of two uprights, which differed clearly in length, to find concealed candy. The pairs of uprights were varied, but for any one child the critical upright under which the candy was concealed was always the longer (or shorter) of the pair. To attain success in this phase of the experiment the subject was required to select the critical upright on eight successive comparisons, by which time he was considered 'to have learned whichever of the concepts "longer than" or "shorter than" he had been taught'. Of the forty-one subjects in the experiment only one failed to learn this initial length discrimination.

The second stage of the experiment was then initiated. Pairs of uprights, differing only slightly in length, were employed. A measuring stick slightly shorter than one upright and slightly longer than the other upright was placed alongside each upright in turn. The subject was then asked to find the candy. In order to gain a measure of perceptual 'discriminability', i.e. to assess whether the subjects could perceive the difference in length between the two uprights, a number of trials were run in which no measuring stick was used. The results showed that, without the measuring stick, in only the top age group (6 years 2 months to 7 years) was the mean number of 'correct' responses above chance level whereas with the measuring stick the mean number of 'correct' responses of the second youngest group (4 years 2 months to 4 years 9 months) and all older groups were significantly above chance level. From this Braine concluded that, from their

observations that upright A was longer than the measuring stick B (A>B) and the measuring stick B was longer than upright C (B>C), the children were able to infer that upright A must be longer than upright C (A>C) and, therefore, children at least two years younger than the age posited by Piaget had transitivity available to them.

Braine's findings, however, have been strongly criticized by Smedslund (1963) who argues that non-transitive hypotheses could account for the results. The perception of upright A longer than measuring stick B leads the child to conclude that the candy is under A without reference to the relationship between measuring stick B and upright C. This, says Smedslund, is a direct application of the child's training. On the other hand, the child could also consider B longer than C, but knowing that B is a measuring stick with no place to conceal candy underneath, he concludes that the candy must be under upright A. A lengthy controversy has ensued between Braine and Smedslund (Braine, 1964; Smedslund, 1965, 1966b), the main points of agreement between them being the need for more data and that the controversy is still open.

The second study mentioned above (Cohen, 1967) looks at the conservation of continuous and discontinuous quantity in two groups of children aged between 4 years 2 months and 5 years 9 months. The control group was given a standard Piagetian task in which two equal glasses were filled with twenty five sweets each. When the child had agreed that they contained equal amounts, the experimenter transferred the contents of one glass to a third glass of

different dimensions and asked: 'Does one glass have more or are they both the same?' The same procedure was used with orangeade and with balls of plasticine, giving three trials per child and a total of thirty control trials.

The experimental group used the same material, but for the 'sweets' test the experimenter showed the child one glass containing twenty-five sweets and said: 'We are going to pretend that there are two children, Mary and Tommy, and we have to share out some sweets between them. We have to be absolutely fair or else there'll be a terrible quarrel. Now these are Mary's sweets and I want you to put Tommy's share in this glass.' The experimenter then gave the child the glass of different dimensions and, if the child allowed for the difference in dimensions when filling it, he was credited with having demonstrated conservation. Again a similar procedure was carried out with orangeade and plasticine giving thirty experimental trials. The results showed that whereas only eight of the control trials were conservation responses twenty-three of the experimental trials were considered to show conservation.

Cohen accounts for the superior results of the experimental group on the basis of:

a. a vocabulary factor involving the removal of ambiguous words such as 'same' and replacing them with words such as 'share'.

b. better motivation because the task purports to have consequences affecting people.

c. participation in the task rather than making verbal.

judgements.

In addition she points out that the control test gave the child the opportunity of arriving at a correct conservation judgement either by an understanding of compensated relations, or by an understanding of identity of invariance and that since the latter was not available to the experimental child he might therefore be expected to do less well.

It is this last point, however, which raises doubts as to the nature of Cohen's experimental task. Conservation as it is defined by Piaget and as it is generally understood involves the notion of the invariance of some empirical factor (e.g. mass, volume etc.) through changes of state (Inhelder and Piaget, 1958). By not providing an invariant transformation Cohen can thus be said not to be studying conservation. However the present writer (1968) using verbal instructions similar to Cohen's, but with establishment of initial equality and the presence of an invariant transformation obtained results comparable with Cohen's.

The whole question of what does and what does not constitute conservation is debatable, though. The procedure in a classic conservation task involves pouring equal amounts of liquid into two identical glass beakers A and B. The subject is asked whether the contents of the two glasses are equivalent or not. If he acknowledges that they are equivalent, then the contents of B are poured into a differently shaped glass B_1 and the subject is again asked whether the contents are equivalent or not.

The subject is then asked to justify his response. According to Inhelder and Piaget (1969), three types of responses are elicited from conservers. Firstly identity responses, e.g. 'it is the same water', secondly reversibility by inversion, e.g. 'you can put the water back into where it was before', or thirdly reversibility by reciprocal relationships, e.g. 'the water is higher, but the glass is narrower, so it's the same amount'.

But what evidence is there that a child who says that the contents of A and B_1 are equal and justifies this on the basis of the reciprocal relationship is not just ignoring the initial equality of A and B, ignoring the transformation from B to B_1 and simply responding, in the way that Cohen's subjects may have been responding, on the basis of compensation between A and B_1? It would appear that the classic conservation tasks, therefore, do not necessarily demand an awareness of the necessity of invariance.

If a child is to make an inference, he needs to be able to remember the premisses he received long enough for him to draw conclusions. Fraisse and Vautrey (1952) suggested that errors typical of Piaget's youngest subjects in length experiments reflect not a peculiarity of their conception of length, but their failure to notice or recall initial information necessary for 'correct' solution. In one of Piaget's tasks two wires equal in length were placed in parallel before the subject so that their end points were not opposed. A bead was moved a certain distance along from the end of one wire and the

child was required to move another bead the same distance along another wire. The pre-operational child moves his bead to a point directly opposite the first bead, thus failing to take into account the differing points of departure of the two beads. This phenomenon Piaget calls 'finalism' and it is interpreted as a reflection that the logical operations basic to measurement are not yet available to the child. Traisse and Vautrey, however, found that subjects who were told to indicate the starting positions of the objects responded correctly more often than subjects whose response was not prefaced by this instruction. Moreover, subjects who made errors had usually indicated the starting position incorrectly, their response being appropriate to the starting position which they had indicated.

Transitive inferences of the form A>B, B>C, ∴A>C are supposedly not available to pre-operational children. However Bryant (1971) and Bryant and Trabasso (1971) claim to have shown that this is not the case provided that they can remember the premisses A>B and B>C. The study used five rods of different colours and lengths. There was an initial training period in which the four comparisons, A>B, B>C, C>D, D>E, were learned. This was achieved by placing pairs of rods in a container in such a way that they projected equally from the top. The child was asked to indicate which rod was 'longer' or 'shorter'. Feedback was given once the child had responded by withdrawing the rods from the containers so that direct comparison could be made. This procedure continued until

the child responded correctly to six successive presentations of each pair. In the experiment that followed the procedure was the same except that no feedback was given. The critical comparison lies in the B>D situation since it contains the only non-adjacent rods which have been seen to be both 'longer' and 'shorter' in the training. The results showed performance well above chance level even with children as young as four. A further experiment in which no visual feedback occurred in the training procedure, the subjects having to remember the comparisons on the basis of being told which of two rods was 'longer' or 'shorter', was carried out. Again the results were well above chance level.

Eric Aronson (personal communication), however, suggests that these results do not necessarily demonstrate transitivity. His criticism is similar to that made by Smedslund in relation to Braine's study (p. 26). He suggests that when presented with the four comparisons A>B, B>C, C>D and D>E, the child learns in the A>B comparison that A is the 'longer' rod and in the D>E comparison E is the 'shorter' rod. In the other two comparisons, B>C, C>D, rod C is common to both and so the child ignores rod C and simply learns that B is the 'longer' rod and D the 'shorter' rod in comparisons other than A>B and D>E. Thus when faced with the critical comparison B>D the child bases his response on previously acquired 'verbal labels' for these two rods, i.e. B is 'longer' and D is 'shorter' whenever rods A and E are not present.

Bryant and Trabasso themselves point out the possibility

of 'verbal labels' being attached to rods A and E and say that comparisons involving these end points 'may have been susceptible to the transfer of absolute responses', but if Aronson's criticism of their study is valid 'absolute responses' may have occurred throughout the whole experiment.

So far in this review of relevant literature we have been concerned with studies coming either from Geneva or based directly on the work of Piaget. We turn now to other studies of children's reasoning. These are not numerous, but they do represent fairly important bodies of work.

One attempt to look at inferential behaviour was made by the Kendlers in a series of experiments (Kendler and Kendler, 1956, 1961, 1962; Kendler et al, 1958). They based their studies on an experimental paradigm, derived from Hull, in which the subject learns three discrete behaviour segments (A-B, X-Y and B-G). In the test situation the subject is presented with A and X and is instructed to 'get G'. The assumption is that inferential behaviour is mediated by an anticipatory goal response to the goal G which moves back to B and then to A via the already learned behaviour segments B-G and A-B. Problem solution, therefore, requires the assembly of A-B and B-G.

The notion of combination to characterize inferential behaviour had earlier been used by Maier (1936) in studies of young children. Maier concluded from his experiments that children of less than five or six were unable to combine elements from different experiences into the single

step which leads to the solution of a problem. The Kendlers (1956) and Kendler et al (1958) on the contrary initially claimed to have discovered this ability in children of three and four. The material they used in the 1956 study was a covered maze-like structure with three points of access which corresponded to the beginnings of the three behaviour segments. The child pulled out a ribbon at access A revealing a toy ladybug (B). This was replaced and a chain at access X was pulled revealing a toy chicken (Y). After this had been replaced a door was removed at access B revealing the toy ladybug again. The child pulled the ladybug thus revealing a toy car (G). The apparatus was then arranged so that only the ribbon(A) and the chain (X) were exposed and the child was instructed to pull the one that would get him the car. The results varied with the order in which the segments (A-B, X-Y and B-G) were presented to the subjects, but over all 71.9 per cent of the subjects made the correct initial choice (i.e. the ribbon at A). This rose to 87.5 per cent in children who learned the behaviour segments in the order X-Y, A-B, B-G. In the 1958 experiment 65 per cent of the subjects made a correct initial choice, but they noted in this experiment that after making the correct initial choice A and thus obtaining the sub-goal B, only one-third of the subjects spontaneously utilized B to obtain the goal G. It became evident at this point in the Kendler s' experiments that correct initial selection of A was not an adequate indication of success in attaining goal G.

Two further experiments were carried out (Kendler and

Kendler, 1961, 1962) in which the subject had to press a button to obtain a marble and then place the marble in a hole before the goal was achieved. In these experiments correct initial selection was at chance level only and very few subjects succeeded in attaining the goal. From their studies the Kendlers concluded that 'when the Hullian paradigm is applied to young children, there is little or no evidence that reasoning or inference occurs' (Kendler and Kendler, 1967).

The type of behaviour which the Kendlers are concerned with is the form of inference which Oléron (1969) describes as 'actually experienced inference', this being the lowest level of the three types of reasoning he mentions (p. 10). Donaldson and Wales (1969b) also refer to the limited nature of the behaviour the Kendlers are studying. They say: 'if one thinks of the organization of complex behaviour as deriving essentially from a process of laying behaviour units end to end, then ... emphasis on temporal sequence is almost inescapable'. They argue further that reasoning need not be an order-preserving replica of the outside world and that theories such as Hull's (on which the Kendler studies are based), which utilize notions such as 'foresight' and 'anticipatory goal reaction', have the 'effect of excluding many of the acts which would by common agreement be classed as inferential'.

Peel (1967) looked at the understanding of implication, incompatibility and disjunction in children between the ages of five and eleven using a 'games technique'. This technique, he says, obviates the need to use 'naturally'

connected propositions and their meaningful associations and at the same time prevents the rejection of the propositions on account of their arbitrariness. The essence of the 'games technique' is that arbitrary rules and relations are accepted as in the rule ace takes the queen.

The procedure of Peel's 'games technique' is that the experimenter has a container of coloured beads and the child a container of coloured counters. An empty box, into which they make their play, is placed between the experimenter and child. The game consists essentially of the experimenter drawing a certain bead, and then the subject drawing a counter depending upon the rule of the particular game.

For implication the instruction was: 'We may each pick any colour we like, but in this game, if and whenever I draw a red bead, you also draw a red counter.' For incompatibility it was: 'We may each draw any colour we like, but in this game, if and whenever I draw a red bead, you are not to draw a red counter.' For disjunction it was: 'We both draw so that there is at least one red in the box between us. I shall draw first, and put my bead in, and then you draw a counter and put that in.' After the instruction had been given the experimenter put either a red bead or a non-red bead into the box between them and the child was required to respond with a counter. A reverse form of the 'game' was also played with the child making the first move, the experimenter responding and the child saying whether the experimenter's response

was right or wrong.

The children were divided into three groups, 5+, 8+ and 11+ and for our purposes it is the responses of the youngest group which are of most interest.

With the implication task the subjects responded on the basis of equivalence giving a red counter in response to a red bead and a non-red counter in response to a non-red bead. In the reverse form of the game when they gave a red counter they accepted a red bead from the experimenter (R.R), but rejected a non-red bead (R.$\overline{R}$). When they gave a non-red counter they rejected a red bead ($\overline{R}$.R) and accepted a non-red bead ($\overline{R}$.$\overline{R}$) from the experimenter. The older children responded in exactly the same way with one exception. This was the $\overline{R}$.R case where the children were judging the experimenter's response. Whereas 76 per cent of the 5+ age group rejected it, 82 per cent of the 11+ age group accepted it. This is interesting in the light of the work of Wason and his colleagues. According to Wason's theory $\overline{p}$.q is considered 'irrelevant' by intelligent adults to the truth or falsity of a conditional. This theory has been confirmed in some test situations (e.g. Johnson-Laird and Tagart, 1969), but in Wason (1968) the $\overline{p}$.q contingency was evaluated as making a sentence false. Wason's subjects are thus producing the same responses as the five-year-olds, whilst the eleven year olds are producing results which accord with material implication.[1] One must, however, guard against reading too much

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1. See discussion of 'growth errors' in Chapter V. Discussion.

into such a situation. The differences between the experimental tasks and the subjects' response patterns as a whole (i.e. responses to other contingencies) need to be accounted for.

The incompatibility situation was handled correctly by the majority of Peel's five-year-olds although 34 per cent of the responses judged the R.R contingency acceptable.

The situation is more confused with disjunction. Peel says the best approximation to the responses of the five-year-olds is disjunction of red bead and non-red counter. In practice what appears to have happened is matching of non-red to non-red when non-red is selected first and a combination of matching red to red and random responding when red is selected first.

Four points are worth noting in Peel's study. Firstly the wording of the instructions is far from simple. The use of the expression 'at least one red' is particularly worrying and the confusion in the disjunction results of the five-year-olds may reflect their difficulty in handling this expression rather than a difficulty in handling disjunction. However in view of Peel's experimental design it is difficult to suggest more adequate alternative terminology.

Secondly, Peel notes that young children match for colour when the experimenter selects a non-red bead, e.g. if the experimenter chooses a blue bead, the subject responds with a blue counter rather than a yellow or green one. He explains this as a 'spread of the implication rule from reds to other colours'. In saying this,

however, he is missing the heart of the matter by not distinguishing between simple colour matching and implication.[1] In fact his implication test encourages colour matching (i.e. red⊃red rather than red⊃green or blue⊃yellow) and fails to produce a situation which discriminates between those subjects who respond on the basis of the necessity of implication and those who simply match colours.

Thirdly Peel's subjects are making their responses from a collection of counters which is 25 per cent red and 75 per cent non-red. It is difficult to say whether this influenced results, but it could have inflated non-red responses at the expense of red responses.

Fourthly, the non-red counters are yellow, blue and green i.e. there are three groups of non-red material as opposed to one group of red material. Peel is studying 'binary propositional thinking', logically this is the case, but psychologically it may not be so. Wales and Grieve (1969) in discussing the difficulties of negation refer to the distinction between antonym pairs which are 'contradictory' i.e. they are 'mutually exclusive and exhaustive' and antonym pairs which are 'contrary' and are infinitely gradable. For example with the 'contradictory' antonym pair 'odd-even', 'not odd' implies 'even' and similarly 'not even' implies 'odd', but with the 'contrary' antonym pair 'hot-cold', 'not hot' lies on a continuum containing 'lukewarm' and 'cold' and 'not lukewarm' does

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1. The distinction between 'matching' and implication will be referred to in Chapter III. Implication.

not imply 'hot'. The 'odd-even' pair, therefore, is symmetrical whereas the 'hot-cold' pair is asymmetrical. However, Wales and Grieve point out that not all 'contradictories' are sym etrical. For example in the 'contradictory' pair 'closed-open' one can have degrees of 'openness', but the same does not apply to 'closed'. Lack of symmetry of this type is akin to the asymmetry in Peel's task where the red and non-red material differ both in quantity and in variety (i.e. red as opposed to blue, green and yellow).

As mentioned above the larger number of non-red counters could serve to encourage non-red responses, but it could also serve to inhibit responses. By this it is meant that a child who is operating on a random selection basis or is using a primitive response rule may select a non-red counter simply because there are more of them whereas a child who is reasoning out the situation may be confounded by the greater complexity of the non-red situation (in terms of type and quantity of non-red material) and may produce a lower level of performance in the non-red selection than in the less complex red selection. This may account for the non-red colour matching responses that Peel found.

The final study to be reported is that of le Bonniec (1970) who is concerned with the modal aspects of reasoning. The study covers a wide area including the modalities of pre-operational, concrete operational and formal operational thinking. Her subjects ranged from three years to thirteen years. In one experiment she used a boy doll and a girl

doll. Each doll had a box containing plastic segments which could be fitted together. In the boy doll's box there were only straight segments, in the girl doll's box there were curved segments. The subjects were shown a bracelet and a stick made of these segments and asked to say whether the boy doll or the girl doll had made them. After they had responded they were asked if the 'incorrect' doll (i.e. the boy doll for the bracelet, the girl doll for the stick) could have made the bracelet (or stick). If the child responded incorrectly he was asked whether there were the same segments in the boy doll's box and the bracelet (or the girl doll's box and the stick).

Between the age of 3 years 6 months and 5 years 1 month there were thirty-six subjects. Five of these failed completely at every stage of the task, eleven failed all except acknowledging that the contents of the girl's box and the stick and the boy's box and the bracelet are not the same and twelve were completely correct. However, as le Bonniec points out the responses these children make are not sufficient in themselves to indicate the kind of 'reasoning' the subjects employed. During the experiment she had, therefore, asked the subjects to justify their responses. Many of the children did not produce justifications, but those who did, justified in terms of factors external to the task rather than in terms of the necessity of the task. The girl doll made the bracelet 'because mothers have bracelets', 'because she didn't know how to make the stick', the girl doll did not make the bracelet 'because she didn't want to', 'because it isn't a live girl'.

It would have been interesting to see how the children responded had the boy doll had the curved segments and the girl doll the straight segments.

In another experiement le Bonniec looked at 'necessity', 'possibility' and 'impossibility'. Her subjects were aged between 4 years 4 months and 8 years 10 months. The youngest group (4 years 4 months to 5 years 1 month) are of interest to us. The material she used consisted of a ball, a stick and a box with a large circular hole and a slit on top. Only the stick could pass through the slit, but both the ball and stickcould pass through the hole. Beneath each opening there was a drawer into which the ball or stick fell. These dawers could be withdrawn. To pass into the box the ball must of necessity go though the hole, it was impossible for it to pass through the slit. It was possible, however, for the stick to pass through both the hole and the slit.

Before the test proper the subjects were shown the material and acquainted with the properties of it by questions such as: 'Can the ball get in the box by passing through the slit?' 'Do you have to put the ball in through the large hole?' 'There is a ball in the box, did it have to go through the large hole?'

In the second pretest stage the subject was acquainted with the need to open the drawers on some occasions and not on others in order to know what was inside the box. The experimenter told the subject that she was going to put the ball and stick into the box and the game was to say whether it was necessary to open the box to find out

which object she had put in. Questions such as: 'I have put a stick in, do you know, without opening the door, which hole it went through?' were asked.

The test itself consisted of a series of four questions asked twice. They were: 1. 'I have put something through the slit; to know what it is do you need to open the drawer or not?' 2. 'I have put something in the large hole; to know what it is do you need to open the drawer or not?' 3. 'I have put a stick in; to know which hole it went through, do you need to open the drawer or not?' 4. 'I have put a ball in; to know which hole it went through do you need to open the drawer or not?' Justifications were required and the results were analysed on the basis of response and justification. An 'adequate' justification for question 1. required reference to the ball not being able to go through the hole, for slit question 2. reference to both the ball and stick being able to pass through the large hole, question 3. reference to the stick being able to pass through both the hole and slit and question 4. reference to the ball not being able to pass through the slit.

Of the twenty-two subjects in the youngest group one responded correctly with adequate justifications on all items. One subject responded correctly and produced 'adequate' justifications for questions 1. and 4., but failed to respond to questions 2. and 3. i.e. he responded and justified his response to the 'necessary'/'impossible' situations, but could not handle the 'possible' situations. Eleven subjects always responded that it was not necessary

to open the drawer and the remaining nine subjects showed a complete lack of comprehension of the task. For all groups other than this group, the most usual response pattern was correct response and 'adequate' justification to the 'necessary'/'impossible' situations and complete failure to handle the 'possible' situations although even in the oldest group (median age 7 years 6 months) six subjects out of thirty-four were still denying the necessity of opening the door at all and one was showing complete lack of comprehension of the task.

The bulk of the studies referred to in this review do not paint a very bright picture of the pre-school child's inferential ability. Most studies deny the existence of such an ability and those which attempt to demonstrate it using new techniques are often open to criticism on methodological grounds.

Piaget has, it could be argued, dominated this review. There is good reason for this. It is not just the sheer quantity of his work which makes him so important, but the fact that like Chomsky in linguistics he has become a reference point in studies of children's reasoning such that the majority of researcher's into reasoning ability define their position with reference to Piaget's theory.[1]

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1. This review of literature is an outline of the main studies in the area. A number of other studies have some bearing on the present enquiry but, in the interests of clarity, these will be referred to at relevant points in the following sections.

C. Some Methodological Issues

White (1969) provides a useful outline of conditions which it is 'usually wise to establish' in experimental procedures with children. He says that one must have 'rapport' with the pre-school child and that one must by-pass a noticeable component of 'stranger anxiety' for many children. The child is praised throughout the task. This praise serves as a kind of feedback to the child informing him that the experimenter finds his behaviour acceptable. It also makes the child feel successful and conveys the experimenter's 'friendly feelings' towards the child. Apart from praise of this nature the experimenter attempts to keep his face expressionless, so that the child will be led to attend to what satisfies the test and not the experimenter. In addition a 'simplified visual environment' is used. The apparatus dominates the child's field of view and possible distractions and other interesting visual material are removed from view. Verbal instructions are short and mixed with actual motor rehearsal of the moves the child will make during the course of the procedure. Finally, at intervals throughout the test the child's goals are recalled to him.

White based these precautions on his experience in conducting a 'discrimination' learning experiment, but suggests that most experimenters who work with pre-school children use similar techniques. Certainly the 'precautions' mentioned above are relevant to the present study.

An attempt to establish 'rapport' and eliminate

'stranger anxiety' was made by the experimenter visiting the nursery school, class or playgroup prior to an experiment. Time was spent mixing and talking with the children when other children and familiar nursery teachers and nursery assistants were close at hand. Perhaps as a result of this procedure only two children refused to accompany the experimenter away from the rest of the children, as soon as they were asked. In one case a boy of three years nine months refused to enter the staffroom where the experiment was to be carried out, but quite happily took part in the experiment in the corridor outside the staffroom. The second case was a girl of three years two months who refused to accompany the experimenter alone, but later agreed when a nursery teacher also came along. The nursery teacher left as soon as the experimental procedure began.

The tasks were designed to be 'intrinsically attractive' for the child. No rewards were given, but it was hoped that the tasks were rewarding in themselves. For example, finding a sought-for object in a box or building a row of houses from pictures of houses which were found when the child responded to a task, can presumably be considered 'rewarding' situations. Verbal encouragement was given by using expressions such as 'good' after the child had made a response. Also the test was always referred to as a game and the child was asked to accompany the experimenter 'to play a game'.

To avoid distraction, testing always took place away from other children. The locations of the testing

ranged from staffrooms, a headteacher's study to a church vestry and in one case a screened-off section of a cloakroom. The testing was conducted with the child and experimenter seated on opposite sides of a low table. Only the experimental material was on the table and possible sources of distraction were removed from the immediate vicinity.

The test material was simple and mostly of a kind which the child might handle in his everyday life e.g. a rubber ball, a toy train, a matchbox. To ensure that the child knew the names of these objects and that failure was not the result of an unfamiliar name, an identification procedure was carried out at the beginning of experiments in which the child had to point out the objects when the experimenter named them and name the objects when the experimenter pointed to them.

Two types of verbal instructions appeared in the experiments, those which conveyed the nature of the procedures, e.g. selecting an object in response to something said by the experimenter, and those which conveyed the verbal premiss by which the subject could make a specific selection. The former type of instruction was repeated at appropriate intervals throughout the experiment to avoid failure to remember the procedure. Although memory limitations may have played a part in responses to the second type of verbal instruction in most cases an immediate response was required and repetition of the premiss would have been inappropriate. In one experiment, though, (Experiment 2. 'Houses and boxes')

in some trials two responses were required following a verbal premiss and a comparison was made between half these trials where the premiss was repeated before the second response and half these trials where the premiss was not repeated.

The attention spans of children are another source of difficulty. The pre-school child's ability to sustain his attention on one particular task is extremely fragile and tends to disappear with only relatively minor distraction. Gollin (1961) has found that distraction which interferes with the ability of a five-year-old to solve a discrimination problem does not interfere with the performance of a seven-year-old and Birch (1966) found that the simple instruction to hold down a lever was adhered to for time lengths which related to the age ofthe pre-school child. The older the child the longer he held down the lever.

A reduction of the distraction element of attention span was attempted in this study by making the task 'attractive' and therefore hopefully attention arousing and by eliminating as many sources of distraction as possible (p. 45). Reduction of the effects of the limited time of the child's attention span was attempted by restricting the length of the experiments to an average of ten or fifteen minutes. In addition, prior to conducting an experiment, a pilot study using children from the Edinburgh Cognition Project nursery was carried out. This pilot study afforded the experimenter an opportunity of ascertaining approximately if there was a

point in the experiment where the child's attention began to wander. A considerable improvement in the usefulness of these pilot studies came about after the first group of experiments had been carried out (Chapter II. Disjunction, Experiments 2 and 3). At this point videotape equipment became available and subsequent pilot studies were recorded and analysed later when the experimenter was less involved in the ongoing procedure of the experiment. This type of analysis of pilot tests enabled the experimenter to modify and refine experiments on a more thorough basis than is available in non-recorded pilot tests.

Typical kinds of modifications made as a result of these analyses were the reduction of trials in an experiment because analysis of the recording revealed lack of attention, reducing the length of an instruction because the child appeared confused and uncertain towards the end of the instruction, eliminating repetitions of instructions concerning the nature of the task because they appeared to be unnecessary and rather than aiding the child to keep the objectives of the task in mind appeared to be inducing a loss of interest and finally repositioning experimental material when it was seen not to fall easily within the child's visual field.

For example, in Experiment 4, it was proposed to run one session of eight trials, but this was changed to two sessions of four trials each because the pilot children's attention appeared to wander after the sixth trial. In Experiment 5 the initial instructions contained a large

repetitive element because it was thought that this would help the child to understand the instructions, but the pilot children showed uncertainty and confusion towards the end of the instructions and so the length of the instructions was considerably reduced resulting in no such evidence of confusion in further pilot tests. Again in Experiment 5 repetition of part of the instruction after each trial was seen to be unnecessary and a source of loss of interest indicated by the child's gaze moving beyond the experimental set-up. Therefore this repetition was eliminated.

One of the difficulties of an adult testing a child is that the child, desiring to please the experimenter, is inclined to produce responses which he thinks the experimenter wants at the expense of adhering to the needs of the task. This has to be borne in mind when assessing studies such as the present one for which no other adequate technique exists at the moment. This difficulty is most extreme in Experiments 5 and 6 where the child is required to make judgements on the 'rightness' or 'wrongness' of responses made by the experimenter, i.e. the child has to judge an adult's behaviour as non-acceptable when his everyday experiences tend to be in the reverse direction and his inclinations are to please and conform with the adult rather than deny the correctness of the adult's behaviour.

Donaldson (197) has tackled this problem by using a 'talking panda' which the children in her study accept as 'younger than themselves' and 'not very clever'. By

means of a speaker concealed in the head of the panda a voice was projected so that the panda appeared to speak to the children. On the assumption that the children would be more willing to criticize this less intelligent, younger creature than adults, an experiment was conducted in which the child was required to judge whether statements made by the panda were true or false. It was found that they were capable of making such judgements in this type of situation.

A pilot study for Experiment 5 attempted to use a similar technique with a hand-puppet. The hand-puppet, which was a cat, was described to the children as being 'very young' and 'not very clever' and the cat was going to play a game, but sometimes he made mistakes and they were to tell him when he was wrong. Experiment 5 was then carried out with the experimenter manipulating the hand-puppet so that it appeared to make the selection responses required by the task.

The results of this venture, however, were rather disconcerting. Rather than eliciting a critical attitude in the children it produced a state of high excitement with the children paying far more attention to the cat than the task. Further it produced a 'protective' attitude towards the cat so that when an 'incorrect' response was made the children denied that it was wrong even though they gave evidence that they were aware of the 'incorrectness'. For example one child actually corrected the cat's response by changing the item selected by the cat for another item yet still denied

that the cat was 'wrong'. Another child smiled and giggled when saying one of the cat's responses was 'correct'.

The Donaldson study involved lengthy pre-experiment familiarization with the 'talking panda'. This would also appear necessary for the hand-puppet technique to stand any chance of success. However, this was not feasible in the present study largely because it would have meant imposing considerable inconvenience on the nursery schools, classes and play groups where space is at a premium and provision of a room or area for testing frequently involves extensive organisation as well as loss of valuable space.

Therefore, it was decided to abandon this procedure and for the experimenter to make the responses, stressing in the instructions that both correct and incorrect responses would be made. Possibly because of this precaution and also the game-like nature of the task this procedure appears, in this study at least, to have been effective in eliciting judgements of 'incorrectness' to the experimenter's responses in Experiments 5 and 6.

D. General Design of Study

A number of ways of presenting this study suggest themselves. For example a progression from simple to less simple in terms of experimental design or from less to more successful or consistent in terms of the subject's level of performance. However, with one exception, an historical presentation has been chosen as more expedient. The one exception is the first experiment reported ('And/or') which was performed later in the study, but because of its direct bearing on the initial group of experiments, has been inserted out of chronological sequence.

Historical presentation, in this study, affords not only a breakdown into three major groups of experiments (disjunction, implication and verbal inferences[1]), but also demonstrates the development of test methods which is an important constituent of the study. In addition it shows more clearly how solutions to problems and questions raised in experiments are attempted in subsequent experiments.

The study has been designed to examine the child's inferential or non-inferential behaviour in a variety of frameworks. The tests cover situations in which the subject has to make:

a. a physical response to a verbal proposition concerning concrete material displayed before him.

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1. The term 'verbal inferences' is used to describe inferential behaviour where the child has to make a verbal response to a verbal premiss in the absence of concrete material. 'Verbal inferences' are examined in Chapter IV.

b. a verbal response to a verbal proposition concerning concrete material displayed before him.
c. a verbal response to a verbal proposition when no concrete material is present.

In addition to tests where the subject is required to draw conclusions himself, he has also been placed in situations where he is required to make judgements of 'correctness' and 'incorrectness' on conclusions drawn by another person (i.e. the experimenter), the reason for this procedure being to give a more definitive picture of what a subject considers compatible and incompatible with a given premiss by presenting him with a wider variety of conclusions than he would normally produce himself.

Negatives as well as positives have also been used in verbal premisses, sometimes as constraints differing from the positive ones and sometimes also as logical equivalents to the positives.

Response patterns have been considered in the light of the test situation as a whole. Therefore strategies of search and object or position preferences have been recorded. In the implication tests a direct comparison has been made between materials differing in their degree of 'relatedness'. At one extreme are objects which, as far as the experimenter can ascertain, are sufficiently 'abstract' and exclusive not to have an experiential relationship for the child, whilst at the other extreme are objects which have a 'relatedness' based on the child's everyday experiences. The question here is whether the child can accept a verbal premiss as dominant over his

experience of such objects.

Two forms of control, against which the experimental results can be checked, have been used. Firstly in tests which require the child to locate a hidden object in a row of boxes on the basis of a verbal premiss, a control group has been asked to perform the same task in the absence of the verbal premiss. This control offers some measure of whether perceptual features of the task or some other process, rather than the verbal premiss may be regulating behaviour.

Secondly some kind of 'standard' of inference against which the children's inferential or non-inferential behaviour can be compared is needed. Formal logic could provide this 'standard', but there is evidence that even highly intelligent adults are not always loyal to formal logic. For example the conditional, 'if p then q', has been found not to be treated in a truth-functional manner (Wason, 1966, 1968, 1969a, 1969b, 1971; Wason and Johnson-Laird, 1970; Johnson-Laird and Tagart, 1969).[1]

The observed 'illogicality' of adult reasoning throws some considerable doubt on Piaget's theory of formal operational thinking which requires a truth-functional treatment of implication (Beth and Piaget, 1966). Wohlwill (1962) says: 'Piaget has ...been repeatedly taken to task for his inclination to see nothing but perfect logic and rationality in adult intelligence. His

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1. Further reference will be made to these studies in Chapter III. Implication.

reliance on the principles of abstract logic as a model for human thinking has blinded him to the question of the breadth and stability of logic as used by the individual'.

Mehler and Bever (1968) draw a distinction between what a person can learn to do and what he is disposed to do naturally within a particular cognitive domain, a distinction analogous ~~with~~ to competence and performance in linguistics. They argue that natural predispositions must be included 'as a fact relevant for a theory of the natural patterns of the psychology of inferences'.

For this experiment the argument of Mehler and Bever is a useful line of approach. The 'standard' against which the children's responses are compared is the performance of a control group of adults carrying out the same tasks. The same tasks, rather than comparable tasks specifically designed for adults, were used because there is evidence (e.g. in the Wason studies mentioned above) that logically equivalent situations can elicit different responses if the task conditions are varied. Using tasks, designed for children, with adults raises the problem of the appropriateness of such tasks for eliciting adult reasoning. The nature of the study, however, is such that the problem of different results as a function of varying task conditions and the problem of using tests, designed for children, with adults cannot both be eliminated. Consequently the former problem was removed on the assumption that, with the tasks in this study, the latter problem was the lesser of the two evils. Moreover by making minor modifications in procedure (these modifications were con-

sidered not to detract from the nature of the task) the second problem was reduced somewhat.

The adult subjects used were restricted to the twenty to thirty age range, this range being widely accepted as intellectually stable. They had backgrounds and hopefully intelligence levels comparable with the children. The occupations of these subjects ranged across primary school teacher, accountant, nurse, joiner, electrician, printer, shop assistant, clerk, typist, machine operator, petrol pump attendant and miner. Because of limited availability of such subjects their use as control subjects was restricted to those situations where the nature and type of adult response was most in doubt.

To avoid inter-task practice and learning effects, no subject was used in more than one experiment. This applied to adults as well as children.

The children used in the tasks came from six Edinburgh nursery schools, nursery classes and playgroups. They were selected from the school or playgroup register on the basis of age and sex so that as nearly as possible, for each experimental group, the mean and median age coincided (thus affording a representative sample of the whole age range) and boys and girls were equally represented.

The age range and mean and median ages were also controlled between groups. Two of the tests on disjunction have comparable age ranges between 3 years 1 month and 4 years 7 months with near equivalent means

and medians. For the remaining disjunction test and all other tests the age range was extended upwards to 4 years 11 months giving these tests comparable age ranges from 3 years 1 month to 4 years 11 months again with near equivalent inter-test means and medians.

CHAPTER II

DISJUNCTION

A. Introduction to Disjunction

Disjunction affords an opportunity of looking at children's ability to act in accordance with verbally presented information. In addition, disjunction can also be used to yield situations where a 'correct' response requires the subject to demonstrate inferential behaviour as defined in the introductory chapter of this study (p. 10). However, before proceeding further with the different types of disjunctive tasks studied in the investigation, it is perhaps desirable to consider what we already know about children's ability to handle disjunction.

About pre-school children very little is known, but one study involving pre-school children has been carried out at the Edinburgh Cognition Project Nursery (Margeret Donaldson and Roger Wales have kindly made the data available). The study forms part of a large-scale investigation of children's cognitive development and is reported here in some detail because it is not available in published form.

Thirty-one children (aged four years six months to five years) were presented with a card matching task in which a standard card of two dimensions (colour and shape) was displayed in front of the subjects. A sequence of comparison cards varying along the same two dimensions was revealed to the subject who was required to press a

button whenever a comparison card, consistent with a given disjunctive instruction, appeared.

In one trial a red circle standard card was displayed with the instruction: 'Every time you see either a red one or one that's a circle, I want you to press the button. You only press the button when you see one that's red or one that's a circle.' Of the thirty-one subjects, only one did not respond to the 'red circle' comparison card. He responded 'exclusively' by selecting some, but not all, 'red non-circles' and some, but not all, 'non-red circles'. Of the thirty subjects who did respond to the 'red circle' comparison card, seven made no other response. These seven subjects were responding to disjunction neither 'inclusively' nor 'exclusively', but 'conjunctively' (i.e. neither 'red or circle or both' nor 'red or circle, but not both', but 'red and circle'). Because of the nature of the task it is impossible to say whether they were failing to differentiate between disjunction and conjunction (i.e. treating 'or' as 'and') or whether they were performing a simple matching task of comparison to standard (i.e. responding only to a comparison identical to the standard).[1] Twenty-three subjects responded 'inclusively' (i.e. 'red or circle or both'), but of these twenty-three subjects only four responded to all possible 'inclusive' comparisons, ten subjects responded to the 'red circle', some 'red non-circles' and some 'non-red circles' and nine subjects responded to the 'red

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1. 'Matching' is discussed in Chapter III. Implication.

circle' plus comparisons consistent with one dimension of the standard only (i.e. they responded to 'red non-circles' or 'non-red circles', but not both). Although the responses of this latter group of nine subjects are 'inclusive' insofar as they included the 'red circle', it may be that the reasoning involved has 'exclusive' qualities. If the subject works on the basis of only one dimension of the standard and ignores the other dimension of the standard, he will produce what appears to be an 'inclusive' interpretation. For example, if he takes red as his basis, he will respond to red shapes (this will include the red circle), not because he is reasoning 'red or circle or both', but simply because he is seeking out 'red' in the comparisons and selecting on this dimension alone. The other dimension, 'circle', plays no part in the operation. It could also be argued that subjects who respond 'inclusively' along two dimensions, but fail to notice all possible 'correct' comparison cards may be utilizing a similar 'exclusive' strategy in which they are seeking out only one dimension at a given time, but switch their attention from one dimension to the other dimension and back again as the experiment progresses. This would be a feasible explanation for the omission of some 'correct' comparisons although other explanations are equally probable.

The results of this experiment indicate that pre-school children can handle disjunction in what appears to be an 'inclusive' manner, but by its very nature and particularly because of the physical presence of the two

dimensions (i.e. the standard card) throughout the experiment, this task may be abnormally conducive to the eliciting of apparently 'inclusive' responses.

Other studies of disjunction have involved older children. They are of two main types. Firstly there have been concept attainment studies in which conjunctive and disjunctive concepts have been compared and the former found easier to learn than the latter (King, 1966; Snow and Rabinovitch, 1969). Similar findings have also been reported for adults (Bruner, Goodnow and Austin, 1956).

The second type of study involves the subject responding to a disjunctive instruction either by selecting a single exemplar which he considers consistent with the disjunction (e.g. Peel, 1967 referred to on page 34) or by selecting all consistent exemplars from a comparison group. This latter procedure was used in the Edinburgh Cognition Project study reported above and was also used by Neimark and Slotnick (1970). They presented subjects aged from nine to fifteen and college students with 'inclusive' (A v B or both) and 'unspecified' (A v B) disjunctive statements. For each statement the subject had to select, from a group of pictures or names of common objects, those items which were consistent with the given disjunction. A typical statement was: 'All things which are birds or are black, or both.' Negatives occurred in six of the eight disjunctions used.

The results showed an increase in 'correct' responses with age (a 'correct' response was an 'inclusive' inter-

pretation in which all possible exemplars had been selected). At nine only 4 per cent of responses were 'correct', at fifteen 26 per cent and with college students 70 per cent. The use of negatives in the disjunctions undoubtedly lowered the success rate.

Apart from errors attributed to 'probable carelessness', two main error types were identified. Firstly, there were those in which the subject treated disjunction as conjunction. This error accounted for 42 per cent of responses at age nine, 37 per cent of responses at age fifteen and 16 per cent of responses with college students. With increasing age, it was more common in the 'inclusive' disjunctions than in the 'unspecified' disjunctions. The second type of error was where the subject gave 'a single class in place of the required combination'. This accounted for 24 per cent of responses at nine, 29 per cent of responses at fifteen and 6 per cent of responses with college students. Again this error was slightly more common in the 'inclusive' than the 'unspecified' disjunctions.

Further Neimark and Slotnick report that an 'exclusive' interpretation of disjunction occurred very infrequently. They say: 'practically no S at any age gives $A.\overline{B} + \overline{A}.B$ for A v B'. Here, however, Neimark and Slotnick reveal an ambiguity in their interpretation of what comprises an 'exclusive' response in their task. They take an 'exclusive' response to be one in which the subject bases his responses on a truth-functional analysis in which

A.B is false, $A.\overline{B}$ is true, $\overline{A}.B$ is true and $\overline{A}.\overline{B}$ is false. He selects items corresponding to $A.\overline{B}$ and $\overline{A}.B$ and rejects those corresponding to A.B and $\overline{A}.\overline{B}$. However, one has to distinguish between a truth-functional analysis of 'exclusive' disjunction and the way in which an individual will respond to an 'exclusive' disjunction instruction. For instance, if someone is told to take 'an apple or an orange, but not both', he will choose only one of the offered items. For example he will select the apple and reject the orange ($A.\overline{B}$). He will not also reject the apple and select the orange ($\overline{A}.B$) since, in practice, this is tantamount to selecting both the apple and the orange (A.B). He is probably aware that $A.\overline{B}$ and $\overline{A}.B$ are both 'acceptable selections, but his response does not generally reveal such awareness.

Perhaps we can talk of 'exclusive' disjunction responses[1] (i.e. truth-functional responses) and 'exclusive' disjunction responses[2] (i.e. responses to 'exclusive' disjunction instructions). In the Neimark and Slotnick experiment the former type of response hardly ever occurs, but the latter may well have occurred. unfortunately, they do not state the exact nature of the errors they described as 'giving a single class in place of the required combination'. They do not say whether such responses included A.B items or not. If they did not, then these errors are the second type of 'exclusive' disjunction response put forward here.

At this point we can perhaps also talk about the nature of 'inclusive' disjunction. A truth-functional

analysis of 'inclusive' disjunction gives A.B as true, $\overline{A}$.B as true, A.$\overline{B}$ as true and $\overline{A}$.$\overline{B}$ as false. An 'inclusive' disjunction response based on a truth-functional analysis requires selection of items corresponding to $\overline{A}$.B, A.$\overline{B}$ and A.B with rejection of items corresponding to $\overline{A}$.$\overline{B}$. However, as with 'exclusive' disjunction one can distinguish between a truth-functional analysis of 'inclusive' disjunction and responses to 'inclusive' disjunction instructions. If this time someone is told he can take 'an apple or an orange or both' and he responds by taking both the apple and orange we do not assume that he is responding conjunctively without awareness of the truth-functional values of 'inclusive' disjunction. Similarly if he takes only the apple, his response is not taken to indicate that he is responding 'exclusively' without awareness of the nature of 'inclusive' disjunction. Here may be the key to understanding some of the 'conjunctive' and 'one class' responses in Neimark and Slotnick's experiment. These responses need not necessarily reflect a 'tenuous comprehension of disjunction' as Neimark and Slotnick suggest, but rather the nature and constraints of the task the subject was asked to perform.

Clearly there is a distinction between a truth-functional analysis of disjunction and the way in which one acts in response to a disjunctive instruction. It is argued here that to present a subject with a disjunctive statement and ask him to select exemplars consistent with it, from a comparison group, places the subject in an ambiguous situation where it is unclear whether he is

expected to make a truth-functional analysis or whether he is expected to respond as he would normally to a disjunctive instruction. The selection he makes from the comparison group is, therefore, dependent not only on whether he handles disjunction 'exclusively', 'inclusively', 'conjunctively' or in some other way, but also upon the way he resolves the ambiguity of the task.

A further point about 'inclusive' disjunction is that one can hypothesize psychological processes which will result in apparently 'inclusive' responses (according to a truth-functional analysis) and yet require no awareness of the truth-functional nature of 'inclusive' disjunction. For example if a subject is given the disjunction A v B and required to select items consistent with this disjunction, he may simply select those items with attributes consistent with A (this would give him $A.\overline{B}$ and A.B) and those items with attributes consistent with B (this would give him $\overline{A}.B$ and again A.B). Such a process involves a simple matching of disjuncts with item attributes and requires no awareness that some items contain an attribute consistent with one disjunct, but not with the other disjunct, and that some items contain attributes consistent with both disjuncts. In fact, once an item has been selected as having one attribute consistent with one disjunct, the other attribute of the item which is relevant for a truth-functional treatment of 'inclusive' disjunction, is immaterial in the 'matching' process proposed here. Nevertheless, this process can result in what appear to

be 'inclusive' responses and may account for 'inclusive' responses found in young children (for example in the Edinburgh Cognition Project study. p. 58).

In everyday language adults generally interpret 'or' in its 'exclusive' sense. Mehler and Bever (1968) say: '...the natural or "primary" interpretation of disjunction is exclusive'. 'Inclusive' interpretation is rare, but can occur when the subject's experience of the context of the disjunction impinges upon the interpretation. Naess (1962) presented seventeen-year-olds with a series of disjunctions and found that they interpreted 'inclusively' disjunctions such as: 'Scholarships in this faculty are awarded to those who are competent in Greek or in Latin'.

The way in which adults as well as children handle disjunction is obviously complex. The nature of the task in which disjunction is presented would appear to contribute to the type of disjunctive response a subject produces. College students sometimes produce responses which appear to be conjunctive, but we know that in their everyday language they generally handle disjunction 'exclusively'. With pre-school children, however, the situation is less clear. We do not know whether their everyday handling of disjunction is 'exclusive', whether it is 'conjunctive' or whether they place some other interpretation upon the word 'or'.

It was, therefore, considered worthwhile to perform a simple test in which 'and' and 'or' were the only variables and in which task constraints, such as those in

the experiments discussed above, were removed as far as possible in order to determine:

a. whether pre-school children would respond differently to statements mediated by the word 'and' and those mediated by the word 'or' and

b. if they respond in different ways to 'and' and 'or' what form does it take, how widespread is it and how consistent within and between subjects.

B. Experiment 1. And/Or

a. Method

The task required S, on the basis of a verbally presented conjunction (A.B) or disjunction (A v B), to select an object or objects from an array of three objects displayed in front of him.

i) Subjects

12 nursery school children (6 boys, 6 girls) aged between 3 years 1 month and 4 years 11 months; mean age 4 years 0 months, median age four years 1 months.

ii) Material

A matchbox, a red rubber ball (diameter 2½") and a red cylindrical stick (length 3", diameter 2/5")

iii) Procedure

The three objects (matchbox, ball and stick) were placed in line in front of S who was seated at a low table. E said: 'I've got a matchbox, a ball and a stick here.' (indicating each object as it was mentioned). E then requested S to 'show me the ball' (matchbox, stick). S was required to point out each object as it was named. The identification of the objects was then repeated with E pointing to each object in turn and asking 'What's this?' and S giving the name of the object in response. All Ss were completely successful in identifying the objects in both the above manners.

The test itself then followed. This consisted of E presenting S with instructions of the following two forms:

a. Give me the matchbox and the stick.

b. Give me the matchbox or the stick.[1]

When S handed the object/s to E, he was told 'Good'. The distribution of objects was then changed and the procedure repeated.

iv) Design

Each combination of two from the three objects was used in the instruction containing 'and' (conjunction) and in the instruction containing 'or' (disjunction) for each S. This gave six trials per S. The conjunction and disjunction instructions were alternated in the six trials. Six subjects commenced with a conjunction and six with a disjunction.

Each S was presented with one of twelve orders. In the twelve orders each combination of two objects occurred with equal frequency in all six trial positions. In addition the objects in each combination were presented equally in both directions (e.g. matchbox and/or ball; ball and/or matchbox) with half of each direction mediated by the conjunction and half by the disjunction.

For individual Ss each combination of objects occurred twice (once in each direction), on one occasion with the conjunction and on one occasion with the disjunction. Each S was also presented with all six possible ways of displaying the material in front of him.

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1. Matchbox, stick and ball were used equally.

b. Results

In response to the conjunction situation (A.B) all twelve subjects, on all trials, selected the two objects mentioned in the instruction. There was complete consistency in the disjunctive situation also, with all subjects, on all trials, selecting one of the two objects mentioned in the instruction. There was no evidence of either position preference (i.e. preference for the right, centre or left object in the array) or object preference. In the disjunctive situation, where such preferences might have manifested themselves, the three positions were selected with almost equal frequency as were the objects, with the matchbox chosen on 13 occasions, the ball on 12 occasions and the stick on 11 occasions.

c. Discussion

It is clear, therefore, that three to five year old children do respond differently to the words 'and' and 'or' and that they do so with a very high degree of consistency. The conjunction is handled 'correctly', not only in formal logical terms, but also in the same manner as adults. Disjunction is handled in its 'exclusive' sense (A v B, but not both). This is the response one would expect from adults in this situation.

It would appear that a 'simple' task such as the one in this experiment, produces not the varied results, as in the experiments referred to in the introduction to this chapter (p. 58), but 'exclusive' responses of a highly consistent nature, even from a child as young as three years one month.

It could perhaps be argued that presenting disjunctions alongside conjunctions will force subjects to differentiate between the two thus forcing an 'exclusive' interpretation on disjunction. However, the fact that half the subjects commenced the test with a disjunctive trial and that these subjects all responded 'exclusively' before conjunction appeared on the scene, disproved this.

Finally, if one considers the way in which adults use disjunction when talking to children, it would appear that an 'exclusive' rather than an 'inclusive' interpretation is more frequently intended. For example, 'We'll go to the zoo on Wednesday or Thursday' is more likely to be intended as and accepted as an 'exclusive' disjunction ~~and not~~ than as an 'inclusive' disjunction. If it is the case that in their everyday lives children encounter 'exclusive' disjunction more frequently than 'inclusive', it is not surprising if this is the interpretation they put upon the word 'or' in a situation where the pressures to respond in one direction or the other, if not removed, are considerably reduced when compared with the more usual experimental situations.

C. Experiment 2. Houses and Boxes

a. Introduction

In this experiment the subject is presented with an array of three boxes (p, q and r). Each box contains a card. Two of the cards are blank and one has a picture of a house on it. The subject has to select the box containing the picture of a house. Before each selection, the experimenter makes a statement providing information relevant to the choice and the subject's task is to select a box or boxes strictly in accordance with this information.

One prerequisite for success in such a task is the ability to accept a verbal statement, given by the experimenter, as a basis for judgement and action which is consistent with the statement. It has already been shown in the previously reported experiment (And/or, p. 68) that, in one task at least, pre-school children can consistently constrain their behaviour in accordance with verbally given statements. Here it is proposed to take the issue further, in a different task, and in addition, in some of the statements presented to the subject, to look at the ability to draw necessary conclusions, i.e. to make inferences (as defined in Chapter I, p. 10), in a disjunctive context.

Four types of statement occur. These are used in conjunction with the instruction to 'find the house'. The first type of statement refers directly to the box which contains a picture of a house. For example 'The house is in the red box'. Statements of this kind will

be referred to as 'simple positive' or 'p'.[1] This statement calls for no inference on the part of the child.

The second type of statement specifies one box which does not contain a picture of a house. For example 'The house is not in the white box'. This will be referred to as 'simple negative' or '$\sim$p' and is used as the negative counterpart of 'simple positive' or 'p'. For success with this statement, the subject has to constrain his selection to one of the two boxes not mentioned in the statement (i.e. box q or box r). To do so he must draw the necessary conclusion that since the house is not in box p, it must, therefore, be in either box q or in box r.[2] It will be noted that, since only one of these boxes contains a picture of a house, theoretically only half of the 'correct' selections will obtain the sought-for picture. This means that if the subject 'correctly' concludes that the house is in box q or box r and on selecting box q finds that the picture is not there, he must then draw another necessary conclusion i.e. that the picture must be in box r. This statement, therefore, can require the subject to make two inferences before he attains his goal. The first inference requires him to combine the verbally given information that a picture of a house is in one of the three boxes (p v q v r) with the

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1. 'p' is used to represent a statement which refers to a single box rather than as a symbol for 'positive'.
2. The drawing of this conclusion (i.e. p v q v r, $\sim$ p, $\therefore$ q v r) cannot be taken to indicate that the subject is aware of the alethic modality of 'possibility' as described by Von Wright. p 11)

verbally given information that it is not in box p in order to draw the necessary conclusion that the picture must be in box q or box r (i.e. p v q v r, ~p, ∴ q v r). The second inference again requires the subject to combine two pieces of information, one being the conclusion of the first inference (q v r), the other being his perceptually obtained information that box q does not contain a picture of a house, in order to draw the conclusion that the picture must be in box r (i.e. q v r, ~ q, ∴r).

The third type of statement contains direct reference to two boxes either of which may contain the picture of a house. For example 'The house is in the red box or in the white box'. Statements of this kind will be referred to as 'positive disjunctive' or 'p v q'. As with the 'simple negative' statements, two selections may be needed before the goal is attained, the second selection being based on an inference of the type made for a 'correct' second selection in a 'simple negative' situation.

The fourth type of statement refers to two boxes which do not contain a picture of a house. For example 'The house is not in the red box. The house is not in the white box'. A successful response to this statement requires the subject to combine the information that a picture of a house is in one of the three boxes (p v q v r) with the information that the house is not in box p and the house is not in box q (~p.~q) in order to draw the conclusion that the house must, of necessity, be in box r (i.e. p v q v r, ~p.~q, ∴r). As with 'simple positive' situations only one selection is 'correct'. This type of

statement will be referred to as 'negative disjunctive' or '$\sim p.\sim q$'.

The wording of the fourth type of statement and reference to it as 'negative disjunctive' calls for some comment. The conjunction of two negated propositions ($\sim p.\sim q$) was chosen as the negative counterpart of statements of the third type because, linguistically, it affords a simpler means of conveying a negated disjunction. The more obvious 'The house is neither in the white box nor in the red box (i.e.$\sim(p \vee q)$) would have presented difficulties extraneous to the actual task since it has been shown (Donaldson, 1970) that children older than those in the present study have considerable difficulties with the word 'neither' and the double negative 'neither ...nor'. In her experiment, children aged from five years to seven years one month completed statements describing attributes of cards. Positive rather than negative attributes of the cards were more frequently given in completing statements commencing with 'neither' and, in those cases where negative attributes were referred to in the responses, only one subject out of a hundred and fifty five used the word 'nor', and she on only one occasion. There were thirteen instances of completion with negative attributes using the word 'or'. It was, therefore, considered wiser in this study to avoid the word 'neither'. The Donaldson study only provides evidence that 'nor' is not used successfully when following 'neither', but since there is no other available evidence to suggest that it is used or understood in other situations and no

evidence to indicate whether it is confused or differentiated from 'or', the word 'nor' has also been avoided.

Logically the conjunction of two negated propositions ($\sim p.\sim q$) is equivalent to the negation of their disjunction ($\sim(p \vee q)$) (de Morgan's rules) and, in this study, in view of the reasons given above, statements of the form $\sim p.\sim q$ are used as negative counterparts of 'positive disjunction' ($p \vee q$) and will be referred to as 'negative disjunctive'.

A two-dimensional summary of the four types of statement is given in Figure 2 below. A third dimension exists, but is not drawn out in Figure 2. This dimension reflects the relationship between diagonally opposed statements where the first and fourth statements (i.e. 'p' and '$\sim p.\sim q$') have one, and only one, 'correct' response and the second and third statements (i.e. '$\sim p$' and '$p \vee q$') have two 'correct' responses and may require a second selection, based on an inference, before the goal, i.e. the picture of a house, is attained. Two of the four statements used

Figure 2

The negative/positive and simple/disjunctive dimensions of the statements used in Experiment 2

	Positive	Negative
Simple	p	$\sim p$
Disjunctive	$p \vee q$	$\sim p.\sim q$ ($\sim(p \vee q)$)

negatives explicitly, a third statement (simple disjunction) has an implicit negative which plays a part in a second selection, if the first selection has revealed the goal not to be present. It should be noted that, even if they are equivalent in the information they convey, negative and positive statements are not psychologically equivalent.

Children begin to use 'no' and 'not' to negative propositions quite early in life. Klima and Bellugi (1966) report examples, from children between the ages of two and three, such as 'He not little, he big' and in response to an adult stating 'That's your valentine', 'No, Becky valentine'. However, the use of negatives in 'formal' experimental tasks with older children and adults has produced an area of considerable complexity. In some tasks negatives have been found more difficult to process than positives (Donaldson, 1959; Wason, 1959, 1961). In one task connotations of 'not' were found to affect response latencies more than the function of 'not' as a logical constant (Wason and Jones, 1963). With children Donaldson (1970) found situations with two negatives no more difficult than those with one negative and one positive and, with adults, Wason (1965) found the difficulties of negation were reduced in contexts where a negative statement denied that an 'exceptional' item had a property of a larger residual class.

From studies such as these, one concludes that the nature of a particular experimental situation plays a part in determining the way in which a subject processes negatives and that, even if informationally equivalent, negative and positive statements, are not necessarily 'psychologically' equivalent.

In the present study we have informationally equivalent negative and positive statements. For example the 'simple positive' is informationally equivalent to the 'negative disjunctive', but the use of one calls for an inference while the use of the other does not. Also we have negative counterparts for each positive statement. For example the 'simple positive' has as its negative counterpart the 'simple negative', but clearly here the 'psychological' processing required for attainment of goal is different for the two statements. One can hypothesize that, with informationally equivalent negatives and positives and with positive and negative counterparts, in this task, pre-school children will find negatives more difficult to process than positives.

The word 'in' was used in the statements with some confidence that it was a preposition with which pre-school children are familiar. Utterances of 'in' have been recorded in the spontaneous speech of two year old children (Brown, Fraser and Bellugi, 1964; Miller and Ervin, 1964) and the present experimenter found, in informal situations, pre-school children, aged three to four, could follow instructions and answer correctly questions such as: 'Put the brick in the box', 'What is in the box?' 'Is the doll in the box?' in situations where a box was empty or had an object in it.

b. <u>Method</u>

For half of the Ss in this experiment, the relevant boxes were indicated by reference to their colour only,

whereas for the other half of the Ss, E indicated the relevant boxes by pointing to them. In the latter condition a typical statement used was: 'The house is in this box' (p). When the word 'this' was spoken, E pointed to the relevant box. These two conditions afforded a comparison between a purely verbal presentation of information and a more usual (for young children) pointing to or touching relevant aspects of the material in conjunction with verbally presented information.

However, there were problems in selecting Ss for the 'colour only' reference condition, since not all pre-school children know colour names. To overcome this, children were tested for their ability to identify the three colours necessary for the experiment (red, white and black) before final selection of Ss took place. Each child was presented with three cards (a red card, white card and black card) and asked of each card in turn: 'What colour is this?' If a child was unable to identify all three colours correctly, he was omitted from the experimental sample and replaced by a child, of as near equivalent age aspossible, who did possess colour names. In selecting the 48 Ss for the 'colour only' reference condition, 7 other children were rejected on the above grounds. To have retained these children in the sample would have involved introducing a confounding variable, extraneous to the task, into the results. Nevertheless, this procedure may have produced a biased 'colour only' reference sample, but there are some grounds for suggesting that this bias may not be in the direction of a

higher intelligence level. It was found, by the present experimenter, with pilot test children whose intelligence quotients were known (Terman-Merrill), that two pre-school children well above average intelligence did not possess these colour names whilst two younger children of average intelligence did. Nevertheless the selection procedure of this experimental group has to be borne in mind when assessing the results.

For half the Ss, if a situation arose where a 'correct' first selection did not reveal the goal (i.e. with statements '$\sim p$' and '$p \vee q$'), E repeated the statement before S made his second selection. For the other half of the Ss the statement was not repeated. This provided some measure of whether failure to make a 'correct' second selection was caused by an inability to remember the essential information or an inability to draw the appropriate necessary conclusion (see reference to memory limitation as a confounding variable. p. 7)

A control group of subjects also performed the task. They had to locate the picture of a house without the aid of the statements and provided a 'standard' against which the 'experimental subjects' performances could be compared. Any difference between the two groups could thus be attributed to regulation of behaviour by the statements.

In addition a group of adults also performed the task (see reference to adult subjects. p. 55).

i) Subjects

Experimental subjects: children

96 nursery school children (50 boys, 46 girls) aged between 3 years 1 month and 4 years 7 months.

Control subjects: children

16 nursery school children (8 boys, 8 girls) aged between 3 years 2 months and 4 years 7 months.

Experimental subjects: adults

12 adults aged between 20 and 30 years (6 men, 6 women).

Control subjects: adults

6 adults aged between 20 and 30 years (3 men, 3 women).

ii) Material

38 cards, 3" by 2½". Twenty-four of the cards were blank and fourteen had on them brightly coloured pictures of houses.

3 unpainted wooden boxes and 3 coloured wooden boxes (one red, one white and one black) measuring 4" in length, 2½" in breadth and 2¾" in height. Each box had a 3¼" slit on its upper surface. The boxes were designed so that cards inserted into the slits in the top protruded by half an inch. The pictures of houses were positioned sufficiently low on the cards for blank and picture cards to appear identical when they were in the boxes.

iii) Procedure

Experimental subjects: children

Each S was tested individually, seated at a low table facing E. E showed S a card with a picture of a house on it and asked: 'Do you know what this is?' All Ss responded that it was a house or a picture of a house.

E, after telling S that his answer was correct, held an identical card in front of S and said: 'and this is another house/picture of a house isn't it?' (using whichever label S had himself offered). After S had agreed that it was another house/picture of a house, E said: 'I'm going to put this house on the table here. Now, you put the other house there next to it.' When S had done this E said: 'I have some more houses here and we're going to play a game to see whether we can find them and make a row of houses across the table. I have some boxes here and I'm going to put a house in one of the boxes and in the other boxes, I'm going to put cards with nothing on, like this.' (at this point S was shown one of the blank cards).

The information was then summarized for S as follows: 'One of the cards has a house on it. The other cards haven't got a house on them.'

The cards were placed in the appropriate boxes out of view of the child. E laid the boxes in a row in front of S and said: 'I'm going to tell you something and then I want you to try to find the house. Listen carefully.'

For the Ss whose attention was drawn to the boxes by E referring to the colours of the relevant boxes, E made one of the following statements:

1. The house is in the red[1] box. (p)
2. The house is <u>not</u> in the red box. ($\sim$p)

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1. Red, white and black were used equally for all subjects and statements.

3. The house is in the red box or in the white box. (p v q)
4. The house is <u>not</u> in the red box. The house is <u>not</u> in the white box. (~p.~q)

For the Ss whose attention was drawn to the relevant boxes by E pointing to the boxes, E made one of the following corresponding statements; pointing as she did so to the appropriate box(es):

1. The house is in this box. (p)
2. The house is <u>not</u> in this box. (~p)
3. The house is in this box or in this box. (p v q)
4. The house is <u>not</u> in this box. The house is <u>not</u> in this box. (~p.~q)

In statements where the word <u>not</u> occured, it was stressed.

If S failed to select a box immediately, E said: 'Where's the house? Try to find it.' This additional instruction was required on relatively few occasions and never more than once by any S.

Whenever S had made a 'correct' choice (i.e. had acted within the limits of the statement), after he had made his choice, but before he had removed the card from the box, he was asked: 'How do you know the house is in that box?' The aim was to see whether S would express any awareness of the 'necessity' of some selections and the uncertainty of others (i.e. with statements '~p' and 'p v q' where two possibilities are open).

S was then asked to take the card out of the box. If S had selected the 'critical' card (i.e. the card with a house on it), he was told: 'That's good, put the house

there next to the other houses.' If the child had chosen a blank card, he was told: 'No, that's not the house, is it?' With statements '~p' and 'p v q', if this blank card was 'correct' (in the sense that it was consistent with the statement), for half the subjects, the statement was repeated at this point with E saying: 'Listen carefully,' followed by the statement. All Ss were then asked: 'Can you find the house now?' If S made a 'correct' second selection with statements '~p' and 'p v q' he was again asked: 'How do you know the house is in that box?' before removing the card from the box. The procedure was repeated until the child eventually found the 'critical' card. Once the 'critical' card had been located and positioned in the row of houses the child was building up E said: 'We'll see if we can find another house now'. E then rearranged the cards in the appropriate boxes, said: 'Listen carefully' and then made the statement for the following trial.

The Ss were never told that they had to select only one box at a time, although, in practice, this is what they did. Since they knew that only one box contained a picture of a house, this knowledge may have been sufficient to restrict their behaviour to single-box selections.

After the last trial S was shown the array of three boxes and was asked, without any preceding statement, to 'take out one of the cards'. The purpose of this was to note any general position and, in the case of the Ss who were presented with coloured boxes, colour preferences amongst the Ss.

Experimental subjects: adults.

Because of the simplicity of the task, it seemed advisable to begin by explaining to the Ss that no trickery was involved and by asking for their serious co-operation in return for an explanation of the purpose of the experiment at the end of the trials. The adult version was modified by omission of a) the introductory familiarization with the picture cards, and b) the references to 'playing a game' and 'building a row of houses'. Otherwise the same procedure was followed as for Experimental group A with E pointing to the relevant boxes and no repetition of the statement between selections.

Control subjects: children and adults.

The procedure was the same as for the experimental Ss except that in each trial the statement was: 'The house is in one of the boxes', the statement was not repeated between selections and no justifications were asked for (i.e. S was not asked: 'How do you know the house is in that box?'). Half the control children performed the task with unpainted boxes and half with the coloured boxes. All adult Ss were presented with unpainted boxes.

iv) Design.

The 96 experimental children were divided into four equal groups, one for each of four experimental conditions. For two of the groups (groups A and B) the relevant boxes were indicated by E pointing to them. For the other two groups (groups C and D) the relevant boxes were indicated by reference to their colour only.

Groups A and C received all four statements ('p', '~p', 'p v q' and '~p.~q') without any repetitions of the statement before a second response. Groups B and D received two statements only ('~p' and 'p v q') and if a 'correct' first response did not reveal the picture of a house, the statement was repeated, by E, before a second response was attempted. Since groups B and D were included for the purpose of studying the extent to which memory limitations affected second responses following 'correct' first responses, only the two statements in which a second response was possible, after a 'correct' first response, were included (i.e. '~p' and 'p v q').

Details of the four experimental groups and the control group are given in Table 1.

Table 1

Composition, age details and experimental conditions of the experimental groups

Group	Experimental Conditions	No.of Ss	Sex	Age		
				Range	Mean	Median
A	Pointing, no statement repeat	24	13 boys 11 girls	3.1-4.7	3.10	3.9½
B	Pointing, statement repeat	24	13 boys 11 girls	3.1-4.7	3.10	3.9½
C	Colour, no statement repeat	24	12 boys 12 girls	3.1-4.7	3.10½	3.9½
D	Colour, statement repeat	24	12 boys 12 girls	3.1-4.7	3.10	3.9½
Control group		16	8 boys 8 girls	3.2-4.7	3.10	3.11

Each of the 24 Ss in group A and each of the 24 Ss in group C was assigned to one of the 24 orders produced by permutation of the four statements.

For each of the four statements there were three conditions (i.e. spatial positions of the box(es) indicated in the statements). Box p was always to the left of the array, box q in the centre and box r to the right (from Ss viewpoint). For 'simple positive' and 'simple negative' the three conditions were 'p', 'q' and 'r'. For 'positive disjunctive' and 'negative disjunctive' the three conditions were 'pq', 'pr' and 'qr'. By repeating an individual S's 'order' of statements three times, all three conditions of each statement were given to each S. This gave a series of 12 trials per S.

For each S, each two-box condition (i.e. 'pq', 'qr' and 'pr') was presented once in a left-right direction and once in a right-left direction (e.g. 'pq', 'qp'). Three left-right and three right-left presentations occurred for each S, with at least one left-right and one right-left presentation occurring with both 'positive disjunctive' and 'negative disjunctive'.

With 'positive disjunctive' the 'critical' box (i.e. the box containing a picture of a house) was the first box indicated, on at least one occasion, and the second box indicated, on at least one occasion, for each S. With the 'simple negative' statements '$\sim$p' and '$\sim$r', on one occasion the 'critical' box was the one adjacent to the indicated box and on one occasion the box furthest from the indicated box. Each box contained the picture

of a house on four occasions for each S.

For group A and group C (i.e. for 24 Ss as a group), each statement occurred 72 times, on 6 occasions in each series position (i.e. 6 times as the first statement presented to S, 6 times as the second statement presented to S, etc.). Each condition occurred 8 times in each series position and each statement/condition combination occurred twice in each series position.

For groups B and D who received 'simple negative' and 'positive disjunctive' statements only, the two statements were alternated for each S, with half the Ss in each group commencing with a 'simple negative' and half with a 'positive disjunctive'. Each statement was presented with all its three conditions to each S, giving 6 trials per S. Direction of presentation with 'positive disjunctive' (i.e. left-right, right-left) and position of 'critical' box with both statements were controlled as for groups A and C. Each statement occurred 72 times, on 12 occasions in each series position. Each condition occurred 8 times in each series position and each statement/condition combination occurred twice in each series position.

The twelve adult experimental subjects were assigned to 12 of the 24 series used for groups A and C, so that for them, as a group, each statement occurred 36 times, on 3 occasions in each series position. Each condition occurred 4 times and each statement/condition combination occurred once in each series position. Direction of presentation and position of 'critical' box precautions

were observed for them in the same manner as with the children.

The positions of the 'critical' boxes for control subjects were the same as for experimental subjects with the 22 control subjects (16 children and 6 adults) assigned to 22 of the 24 sequences of 'critical' positions used in the trials of groups A and C. This gave 12 trials per control S with the picture of a house occurring in each box on four occasions.

When coloured boxes were used, the six orders resulting from the permutation of these colours were used for boxes p, q and r. Ss were allocated equally to these orders.

c. Results

i) Experimental subjects: children

First responses

Table 2 gives the number of correct and incorrect first responses for each of the four statements used (i.e. the number of first responses which are compatible and the number of first responses which are incompatible with the statement). In addition it gives the number of subjects whose first responses are always correct on all three occasions on which they respond to any particular statement and the number of subjects making at least one incorrect first response to a particular statement.

Table 2

Number of correct and incorrect first responses and number of subjects making correct and incorrect first responses

	p	~p	p v q	~p.~q
No.of correct responses	141 (97.9%)[1]	247 (85.8%)	272 (94.4%)	112 (77.8%)
No.of incorrect responses	3	41	16	32
Total no.of responses	144	288	288	144
No.of Ss consistently correct	45 (93.8%)	72 (75.0%)	81 (84.4%)	29 (60.4%)
No.of Ss with at least one incorrect response	3	24	15	19
Total no.of Ss	48	96	96	48

For statements 'p' and '~p.~q' the probability of a correct response by chance is one in three since one box out of the three is compatible with the statement. For statements '~p' and 'p v q' the probability of a correct response by chance is two in three since two out of the three boxes are compatible with the statement. For each of the four statements correct first responses are significantly above chance level ($p<.001$).[2]

1. Percentages of correct responses and Ss making consistently correct responses.
2. The χ^2 test has been employed throughout this study and levels of significance have been obtained from Table C of Sigel, S. Nonparametric statistics for the behavioral sciences

If one takes the percentage of correct first responses as an indicator of the degree of difficulty of each statement, then statement 'p' is the least difficult with statements 'p v q', '~p' and '~p.~q' becoming increasingly more difficult.

The major source of difficulty appears to lie in negation. Since the writer has been unable to find a statistical test which handles data of this type adequately, levels of significance have not been computed. Nevertheless the number of incorrect first responses for the negative statements (i.e. '~p' and '~p.~q') is higher than for the positive statements (i.e. 'p' and 'p v q'). A closer analysis of negatives and positives shows that for each negative statement there are more errors than for its positive informational equivalent (i.e. there are more errors for '~p' than for 'p v q' and more errors for '~p.~q' than for 'p'). Also for each negative statement there are more errors than for its positive counterpart (i.e. there are more errors for '~p' than 'p' and more errors for '~p.~q' than for 'p v q').

Although it is possible to ascertain an order of difficulty for the statements from the results as a whole, the situation is less clear when one examines the results of individual subjects. Here seven subjects produce incorrect responses for statement 'p v q', but are consistently correct with negative statements and none subjects are incorrect with statement '~p', but are always correct with all other statements.

Age differences

An analysis of the frequency of incorrect first

responses according to age reveals that subjects aged 3 years 9 months and younger (this represents exactly half of the subjects in the experiment as a whole and exactly half the subjects presented with each statement) produced significantly more incorrect first responses than the subjects older than 3 years 9 months ($p<.001$). Only 17 of the 48 subjects in the younger group were consistently correct with each statement whereas 40 of the 48 subjects in the older group were consistently correct with each statement. Nevertheless, the number of correct first responses, for each statement, was still well above chance level for the younger half of the subjects ($p<.001$ for 'p', 'p v q', '$\sim p.\sim q$'; $p<.01$ for '$\sim p$'). Table 3 gives the number of incorrect responses occurring according to age.

Table 3

Number of incorrect first responses according to age

	p		$\sim p$		p v q		$\sim p.\sim q$		All statements	
	IR	R	IR	R	IR	R	IR	R	IR	R
3.9 and younger	3	72	30	144	11	144	24	72	68	432
Older than 3.9	0	72	11	144	5	144	8	72	24	432
All Ss	3	144	41	288	16	288	32	144	92	864

IR = no. of incorrect responses

R = no. of responses

Colour names vs. pointing

For half the subjects in this experiment the relevant boxes were indicated by reference to their colour only, whereas for the other half of the subjects the relevant

boxes were indicated by the experimenter pointing to them. Although there were slight variations for each statement, identical totals of correct first responses were produced in the 'pointing' and 'colour naming' conditions. Table 4 gives the number of correct responses in these two conditions.

Table 4

Number of correct first responses in 'pointing' and 'colour naming' conditions

	p	∧p	p v q	∼p.∼q	All statements
Pointing	71	124	136	55	386
Colour naming	70	123	136	57	386

Second responses

The main interest in second responses lies in cases where the statement leaves two correct alternatives open (i.e. '∧p' and 'p v q'). With statements 'p' and '∼p.∼q' a second response indicates that the first response was incorrect. With statements '∧p' and 'p v q' a second response can follow an incorrect first response. In this case the second response has to be correct since only one box is incompatible with the statement. In addition though, second responses for these two statements ('∧p' and 'p v q') can follow correct first responses which are compatible with the statement, but do not produce the picture of a house. It is second responses of the latter type which are particularly relevant here, since they

require the subject to make an inference based on the information he gains from the statement plus the information he gains from not finding the picture of a house in his first response.

In order to gain some measure of memory effects in this experiment, for half the subjects, second responses to statements '$\sim p$' and '$p \vee q$' were preceded by a repetition of the statement. For the other half of the subjects no repetition of the statement was made. Table 5 indicates, for statements '$\sim p$' and '$p \vee q$', the number of correct second responses following correct first responses in the 'statement repeated' and 'statement not repeated' conditions.

Table 5

Correct second responses following correct first responses

	$\sim p$			$p \vee q$			Both statements		
	No. of second resps.[1]	Correct second resps.		No. of second resps.	Correct second resps.		No. of second resps.	Correct second resps	
		No.	%		No.	%		No.	%
Statement repeated	71	64	90.1	63	59	93.7	134	123	91.8
Statement not repeated	60	47	78.3	69	59	85.5	129	106	82.2
Total	131	111	84.7	132	118	89.4	263	229	87.1

1. These are second responses following correct first responses and similarly the correct second responses are only those which follow correct first responses.

The number of correct second responses is significantly above chance level ($p<.001$) for each statement in the 'statement repeated' and in the 'statement not repeated' conditions. However a comparison of the two conditions reveals that there are significantly more correct responses ($p<.05$) in the 'statement repeated' condition than in the 'statement not repeated' condition.

ii) Experimental subjects: adults

Only three incorrect responses occurred with the adult subjects, one in each of the three statements 'p', '$\sim$p' and 'p v q'. In two of these cases ('p' and 'p v q') the incorrect response was the first response in the trial and perhaps reflects a distrust of the information.

iii) Search patterns: control and experimental subjects

For the control children there was a significant tendency ($p<.001$) to select the left-most box as the first response. This occurs with both the coloured and uncoloured boxes, though it is less marked with the coloured boxes where a preference for the red box, as opposed to the black and white boxes, appears to play a part. With adults no such preference for the left-most box occurs. With adults there is a slight, though non-significant, tendency to select the right-most box. Table 6 gives the frequency of selection of the left, centre and right boxes by both children and adults for first responses.

Table 6

First response selections for control groups

	left box	centre box	right box
Uncoloured boxes	50	23	23
Coloured boxes	43	25	28
All control children	93	48	51
Adults	20	21	31

The tendency to select the left-most box is also evident with the experimental children. With statement 'p v q' where two alternatives are open and one of these is the left box, then the left box is selected in 62 per cent of the children's responses. This is significantly above chance level ($p<.001$). For adults the percentage of such selections is near chance level at 48 per cent. Statement '$\sim p$' which also afforded two choices was subject to this strategy only when '$\sim p$' referred to the centre box. When '$\sim p$' referred to the right-most box another strategy operated. This will be discussed below.

At the end of the experiment, when both experimental and control subjects were asked, without any preceding statement, to 'take out one of the cards' again the preference for the left-most box occurs with the children, but not the adults. Selection of the left-most box is significantly above chance ($p<.001$). Table 7 gives the selections made by children and adults.

Table 7

Selections made in response to 'take out one of the cards' at the end of the experiment

	left box	centre box	right box
Children	56	34	22
Adults	4	8	6

Whenever the control children selected either the left-most box or the right-most box and did not find the picture of a house there was a significant tendency ($p<.001$) for the second response to be the the adjacent centre box. The children appeared to be employing a search strategy in which they worked along the array from left to right or from right to left until they located the picture of a house. Adult subjects did not utilize such a strategy. Table 8 shows the position of second responses after a left-most or right-most response.

Table 8

Position of second response after a left or right box response

First response	left box		right box		left box or right box	
Second response	centre box	right box	centre box	left box	centre box	left or right box
Children	58	2	27	4	85	6
Adults	6	5	8	11	14	16

A further example of the tendency to select the centre box when the left or right box does not contain

the picture of a house is found with statement '$\sim p$'. Whenever '$\sim p$' refers to either the left box or the right box, the adjacent centre box is the first response on significantly more occasions ($p<.001$) than the equally correct non-adjacent box. Table 9 gives the frequency of selection of the adjacent centre box and the non-adjacent box when '$\sim p$' refers to either the left or the right box.

Table 9

Frequency of adjacent and non-adjacent responses to statement '$\sim p$' when '$\sim p$' is either the right box or the left box

Adjacent responses	Non-adjacent responses
134	32

Colour preferences

For the subjects who were presented with coloured boxes a further selection preference was noted. This was the tendency to select the red box in preference to either the white box or the black box. For the control subjects there was a tendency to choose the red box as the first response, although this was not above chance level. Table 10 gives the frequency of selection of the red, white and black boxes as first responses by the control children.

Table 10

First response selections for control group

Red	White	Black
39	27	30

Selection of the red box when it was one of two correct alternatives open for statements '~p' and 'p v q' was not above chance level. In response to the final instruction to 'take out one of the cards', however, for experimental and control subjects preference for the red box was significantly above chance level ($p<.01$). Table 11 gives the frequency for each colour in response to this instruction.

Table 11

Selections made in response to 'take out one of the cards' at the end of the experiment

Red	White	Black
29	14	13

Other possible search patterns were followed up, but were shown not to have influenced the children's responses. For example it was thought that children might select as their first responses the box which contained the picture of a house on the preceding trial. This was found not to be the case. With the control children repetition of the immediately preceding 'reward' box was almost at chance level with 62 such selections out of 192 responses (32.3%). With adults the picture was different. There was a significant tendency not to choose this box ($p<.05$). Out of 72 responses only 16 (22.2%) were selections of the immediately preceding 'reward' box. This adult response pattern was not unexpected since it conforms with a tendency to switch a prediction away from a previously occuring outcome (Cohen, 1960)

It was further thought with statement 'p v q' that there might be a bias towards selecting either the first or second mentioned box, but this was not the case and first and second mentioned boxes were selected with almost equal frequency by both children and adults.

Justifications

Attempts to obtain justifications from the experimental children in response to the question 'How do you know the house is in that box?' were almost completely unsuccessful. On many occasions the children did not respond at all or they simply pointed to the box they had chosen. Of the answers that were given, typical examples were, 'It's in here', 'It pops up', 'I knowed', 'I just know', ''Cos I know you put it in there', ''Cos it's got a house in it'. Some of the children responded quite reasonably that the experimenter had told them, for example, 'You told me', 'You said it', 'Somebody told me'. This type of answer was not unlike some of the replies obtained from the adult subjects, for example, 'You said it was in there', 'You said it's not in that box'. Generally, however, the adult replies were a modified repetition of the information given to the subject and/or some indication of the necessity of the conclusion, for example, 'Well if it's not in there and it's not in there, it must be in here', 'It has to be here', 'If what you say is right, it should be in here'. Only one child produced a justification of this type and this was not a response to the question, but a spontaneous comment. He said, 'It's not in that box 'cos I've looked in there, it's got to be in this box'.

d. Discussion

There is clear evidence in this experiment that even the younger half of the subjects are capable of behaving in accordance with verbally presented information and in addition that they are capable of drawing conclusions from information in which the conclusion is not explicit, but only implied. According to the definition of inferential behaviour used in this study (p. 10) these children have shown themselves to be capable of making inferences. However, for children of three years nine months and younger these capabilities are not consistent (31 of the 48 subjects made at least one incorrect response). Over three years nine months, though, there is a high level of consistency with all except 8 of the 48 subjects consistently correct.

As was predicted in the Introduction to this experiment (p. 78) negative statements proved more difficult than positive statements, but even so negative statements were still handled well above chance level.

Perhaps the most disturbing feature of the findings is the almost complete absence of verbal justifications. It could be argued that this indicates that the children, although capable of making a correct response, are operating at a level which involves no awareness of the necessity of the conclusions they draw. Certainly one has to accept this as a possibility, but other explanations for the absence of justifications are feasible. For example, it does not follow that being aware of the necessity of a conclusion occurs along with the ability

to describe this necessity verbally. Also it is possible that the children did not understand the question they were asked either because the experimental task appeared so self-evident as not to be amenable to explanation or because the language used was not within their comprehension.[1]

Some of the findings of this experiment have relevance for testing children in a wide variety of experimental situations. The finding that conveying information by pointing at relevant attributes of the situation is no more conducive to successful responses than using only verbal colour names suggests that children of this age are capable of operating at a level which does not require physical emphasis of critical aspects of an array. The desirability of conveying or emphasizing information by physical rather than verbal means is widely accepted in much experimentation with young children. Certainly it would appear to be a useful attention directing technique in certain situations, but in other situations it may well be either superfluous or an unnecessary complication of testing method. It has to be remembered though, that in this experiment the children subjected to the 'colour naming' condition were slightly biased as a sample, since seven original subjects were rejected on the grounds that they did not possess the relevant

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1. The language used in questioning children will be considered further in the following chapter on implication.

colour names (p. 79). Nevertheless this is only a small proportion of the total sample of 48 children and the high success rate of this group indicates that verbal conveying of information is a viable procedure with pre-school children.

The significantly better performance which occurred when the statement was repeated before a second response than when the statement was not repeated lends some support to the argument that memory limitations are a cause of failure amongst young children performing cognitive tasks (p. 7). Nevertheless the results from the subjects who did not have the statement repeated indicate a high level of retention of information.

A number of search patterns and preferences operated throughout this experiment. On the whole they appeared not to have influenced the responses of the experimental subjects to the extent of taking precedence over the information conveyed to the subjects in the four statements. For the experimental subjects they appear to have played a secondary role to the statements in directing responses. Where no such statement was given, as with the control subjects, and where the search strategies and preferences do not conflict with the statements, then there is considerable evidence that subjects do not respond randomly. In contrast, the adult subjects appear considerably less influenced by search strategies and preferences (or at least by the search strategies and preferences employed by the children).

The kinds of search patterns found here have relevance for other experimental situations, since it is not unreasonable to suppose that in other choice situations similar, if not the same, strategies will be employed by young children. In this experiment these strategies appeared secondary to the task, but in other situations they could play a more dominant part.

The preference shown for the red box as opposed to the white or black box is perhaps easy to understand on the basis of the relative attractiveness of the three boxes. The tendency to select the left-most box, however, defies explanation at the moment. The 'end-to-end' (i.e. left to right or right to left) search strategy employed by the control children is interesting and somewhat impressive since it reflects a highly systematic and economical search strategy when compared with the apparently largely random procedures employed by the adults.

The tendency with statement '$\sim p$', to select the centre box when '$\sim p$' refers to either of the end boxes may be another example of the 'end-to-end' search strategy. Alternatively, however, it could reflect a preference for the centre box in this situation or a preference for an adjacent response. An adjacent response need not be part of an over all 'end-to-end' strategy, but in this three box situation is indistinguishable from such. Indeed the 'end-to-end' strategy of the control subjects could also be explained on the basis of a preference for the left or the right box followed by selection of each adjacent box.

Search strategies of the type found in the experiment have been noted by other experimenters working with young children. Olson (1966) carried out an experiment with three, five, seven and nine year-old children in which several matrix patterns were displayed in front of the subject. These patterns had some features in common and some features which were peculiar to each pattern. For example two of the patterns were a horizontal line and a 'T' shape. Here the horizontal line was common to both patterns whilst the vertical line occurred only in the 'T' pattern. The subject's task was to determine which pattern was 'correct'. In order to do this he was presented with a 'bulb-board' on which the bulbs, corresponding only to the 'correct' pattern, would light up when pressed. Three types of response were possible. Firstly, bulbs corresponding to neither pattern could be pressed. In this case the bulbs did not light up and the child gained no information to help him distinguish between the correctness of the two patterns. Secondly, bulbs corresponding to the features common to both patterns could be pressed. Here the bulbs did light up, but again no information, enabling the 'correct' pattern to be distinguished, was obtained. Thirdly, bulbs corresponding to one pattern and not the other could be pressed. These bulbs were crucial to distinguishing between the two patterns since they lit up if one pattern was 'correct' and not if the other pattern was 'correct'. It was responses of this third type which had to be made before the subject could

with certainty select the 'correct' picture. Olson refers to these three response types as 'off-pattern redundant positions', 'on-pattern redundant positions' and 'on-pattern informative positions.'

Olson found a highly significant tendency for his three year-old subjects to respond with what he calls a 'search strategy'. This he describes as a 'quasi-systematic search characterised by 'a high predominance of corner bulb presses followed by the pressing of an adjacent bulb' and by 'the occurrence of runs of from four to over fifteen neighbouring bulbs in a sequence that could hardly be random'. In a two pattern discrimination 90 per cent and in a three pattern discrimination 100 per cent of Olson's three year-old subjects responded in this way. By age five children making this type of response had fallen to 24 per cent in a two pattern discrimination and 60 per cent in a three pattern discrimination. At seven years only 8 per cent responded in this way in a two pattern discrimination and 12 per cent in a three pattern discrimination and by nine years none of the children produced this response. There were twenty subjects in the three-year-old group and twenty-five subjects in each of the three older groups.[1]

The tendency for young children to make 'adjacent' responses has been reported by Wales and Campbell (1970). The experiment they describe was designed to study pre-

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1. Other types of response found by Olson will be discussed in Chapter III. Implication.

school children's understanding of superlatives and comparatives. Four objects of decreasing dimensions were placed before the child who was asked to give the experimenter firstly the biggest object and then the wee-est object. Most children correctly selected the biggest object, but at three-and-a-half well over half the subjects and at four-and-a-half almost half the subjects failed to selected the wee-est object. Instead there was a significant tendency to select the object adjacent to the first response. In another part of the same experiment, the experimenter pointed to the second largest object and asked the child to give him an object which was wee-er. Again at three-and-a-half the majority of the children selected the adjacent as opposed to the equally acceptable non-adjacent object.

If one considers the available evidence on the search strategies of these young children it appears that when presented with an array of objects in which one object is singled out for attention (as in the '$\wedge$p' situation and in the Wales and Campbell experiment where an object was pointed to by the experimenter) the child selects an object adjacent to the singled out object. When no object is singled out for attention an extreme object is selected by the child and this is followed by selection of successive adjacent objects. It is unclear whether selection of an adjacent object is normally followed by selection of successive adjacent objects since Wales and Campbell noted a marked tendency for their subjects not to make a second selection when asked if

there was another object 'wee-er' than the one indicated by the experimenter and although second selections of successive adjacent objects were made in the '~p' situation in the 'Houses and boxes' experiment, the task constraints were such that a 'correct' second selection had to be adjacent to the first selection. Further experimentation would be required to clarify this and to determine whether the search strategies noted so far are based on some common strategy or whether a number of strategies are operating.

D. Experiment 3. Disjunctive Syllogism

a. Introduction

The final experiment in this section on disjunction used the same procedure and material as the 'Houses and boxes' experiment, but presents the child with information in the form of the disjunctive syllogism ($p \vee q, \sim p, \therefore q$). To be successful the child has to combine the information from the statement '$p \vee q$' with that from the statement '$\sim p$' and then draw the necessary conclusion 'q'.

The situation in which the child is placed when presented with the disjunctive syllogism is very similar to that of a child making a second response, following a first 'correct' response which has not revealed the picture of a house, to statement '$p \vee q$' in the 'Houses and boxes' experiment. In both cases the child receives the verbally presented information '$p \vee q$' and in both cases the child receives the information '$\sim p$'. In the 'Houses and boxes' situation '$\sim p$' is conveyed by the child seeing that the picture of a house is not in box p and thus box p once emptied of its card is no longer available for selection. With the disjunctive syllogism, however, '$\sim p$' is conveyed verbally and a card is present in box p when the child makes his selection.

b. Method

For half the Ss the relevant boxes were indicated by E pointing to them and for the other half of the Ss the relevant boxes were indicated by reference to their colours only. As in the 'Houses and boxes' experiment

those children in the 'colour only' reference condition were tested for their ability to identify the three colours necessary for the experiment. One of the twelve children in this condition failed to identify the three colours and was replaced by another child, of the same age, who did possess the three colour names.

i) Subjects

24 nursery school children (12 boys, 12 girls) aged between 3 years 1 month and 4 years 6 months.

ii) Material

As for the 'Houses and boxes' experiment (p. 81).

iii) Procedure

As for the 'Houses and boxes' experiment (p. 81) except that:

a. The statements used were:

The house is in this box or in this box (p v q). The house is not in this box (~p)

and

The house is in the red box or in the white box (p v q). The house is not in the red box (~p).[1] [2]

b. Only one response per trial was allowed. If this response resulted in selection of the 'critical' box E said: 'That's good, put the house up there next to the other houses'. If the response was incorrect E said:

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1. The word not was stressed.
2. Red, white and black were used equally for all subjects and statements.

'No that's not the house is it?' Whether the response was correct or not E then said: 'We'll see if we can find another house'. E then rearranged the cards in the appropriate boxes, said: 'Listen carefully', and then made the statements for the following trial.

c. No attempt was made to obtain justifications from the children.

d. Position and colour preferences were not sought at the end of the trials.

iv) Design

The twenty-four subjects were divided into two equal groups, one group for the 'pointing' condition and one group for the 'colour only' condition. Details of the two groups are given in Table 12.

Table 12

Composition, age details and experimental conditions of the two groups

Group	Experimental Condition	No.of Ss	Sex	Age		
				Range	Mean	Median
A	Pointing	12	6 boys 6 girls	3.1-4.6	3.9½	3.9½
B	Colour only	12	6 boys 6 girls	3.1-4.6	3.10	3.9½

The disjunctive syllogism in this three box situation provides six conditions (i.e. spatial positions of the boxes indicated in the statements). If we take box p to be the left box, box q the centre box and box r the right box. these six conditions are 'p v q, ~p', 'p v q, ~q', 'p v r, ~p', 'p v r, ~r', 'q v r, ~q' and 'q v r, ~r'.

In addition the 'p v q' statement in the disjunctive syllogism can be presented in a left-right or right-left direction (i.e. p v q, q v p). Thus we have six conditions with two 'directions' of statement 'p v q' for each condition. This gives 12 trials per S with each condition/'direction' combination occurring once.

For groups A and B (i.e. for 12 Ss as a group) each condition/'direction' combination occurred 12 times, once in each series position (i.e. once as the first trial, once as the second trial, etc.).

When coloured boxes were used, the six orders resulting from the permutation of these colours were used for boxes p, q and r. Ss were allocated equally to these orders.

c. Results

Table 13 gives the number of correct and incorrect responses, the number of subjects who are consistently correct on all twelve trials and the number of subjects who make at least one incorrect response for the two experimental conditions.

The probability of a correct response by chance is one in three and for both experimental conditions the number of correct responses is well above chance level ($p<.001$). The performance in the 'colour only' condition is slightly, but not significantly, better than that in the 'pointing' condition.

Table 13

Number of correct and incorrect responses and number of subjects making correct and incorrect responses

Condition	Pointing	Colour	Both Conditions
No. of correct responses	112(77.8%)	122(84.7%)	234(81.3%)[1]
No.of incorrect responses	32	22	54
Total no. of responses	144	144	288
No.of Ss consistently correct	7	8	15
No.of Ss with at least one incorrect response	5	4	9
Total no. of Ss	12	12	24

Again, as in the 'Houses and boxes' experiment, the younger half of the subject (i.e. the twelve subjects aged 3 years 9 months and younger) produced significantly more incorrect responses ($p<.001$) than the older half of the subjects (i.e. the twelve subjects aged over 3 years 9 months). The younger half made 41 incorrect responses compared with 13 from the older half. Ten of the twelve older subjects were consistently correct whereas only five of the younger twelve subjects were consistently correct. Nevertheless, the number of correct responses obtained from the younger twelve subjects is still well above chance level ($p<.001$).

Two type of incorrect response were possible. Firstly there was selection of the position negated by the '$\sim p$'

1. Percentage of correct responses.

statement and secondly there was selection of the position not mentioned in the disjunctive syllogism. The latter type of incorrect response was most common and accounted for 36 of the 54 incorrect responses. This difference is significant ($p < .02$).

d. **Discussion**

As in the 'Houses and boxes' experiment there is clear evidence of pre-school children's ability to make inferences. This ability is not consistent in the case of younger children in this age range, but over the age of 3 years 9 months there is a high level of consistency.

The most common incorrect response took the form of selection of the box not referred to in the disjunctive syllogism. It is difficult to explain this, but two possibilities suggest themselves. Firstly one could hypothesize some form of generalization of negation from the '~p' box to the other box referred to in the disjunctive syllogism and secondly it may be that memory limitations sometimes prevent retention of the first part of the disjunctive syllogism (i.e. 'p v q') and the subject is responding on the basis of the second part of the disjunctive syllogism (i.e. '~p'). This would mean that selection of the correct box (according to the disjunctive syllogism) and the non-mentioned box should be equally probable.

The disjunctive syllogism is similar to a second response following a 'correct' first response to statement 'p v q' in the 'Houses and boxes' experiment (see Introduction to this experiment. p. 109). However the

percentage of correct responses in the disjunctive syllogism (81.3%) is lower than that in the 'Houses and boxes' experiment (93.7% when the statement was repeated before the second response and 85.5% when the statement was not repeated). This is not surprising, though, when one considers that in the disjunctive syllogism all three boxes contain cards when the subject makes his response whereas in the 'Houses and boxes' experiment one card (the '~p' card) has already been removed. In addition, in the 'Houses and boxes' experiment the precentage of correct responses is based on second responses following a correct first response. It does not take account of incorrect first responses to statement 'p v q'. There were 6.6 per cent incorrect first responses. If one takes the incorrect responses at the two stages in the 'Houses and boxes' experiment to be additive, then performance on the disjunctive syllogism is not very different from performance in the 'Houses and boxes' experiment and, if anything, is slightly better than the condition where the statement is not repeated in the 'Houses and boxes' experiment.

CHAPTER III

Implication

A. Introduction to Implication

The evidence we have available on the way pre-school children might be expected to handle implication, i.e. statements in the form 'if p then q', is very limited indeed. From the findings of le Bonniec (1970) it would appear that such children do not possess the grasp of necessity, impossibility and possibility which is essential for an implication task (see p. 39). Peel (1967) working with five-year-old children found that implication was treated as equivalence, although he did find that with increasing age (up to 11 years) there was a marked tendency for the ~p.q contingency to be considered as incorrect by subjects judging the acceptability or non-acceptability of responses made by the experimenter (see p. 35).

A similar tendency to treat implication as equivalence has been reported by Matalon (1962). With thirty subjects aged between 9 years 3 months and 11 years 6 months he used a red and a green light hidden behind doors and statements of the form: 'If the red light is lit, then the green is lit'. The procedure involved revealing one of the lights to the subject so that he could see whether it was lit or

not. The subject was then asked about the second concealed light. Matalon found that 27 subjects responded correctly to the modus ponens situation and 15 subjects responded correctly to the modus tollens situation (i.e. they said the green light would be lit when the red light was seen to be lit ($p.\cdot.q$) and the red light would not be lit when the green light was seen not to be lit ($\sim q.\cdot.\sim p$)). With the two 'intermediate' situations only 6 subjects when the red light was seen not to be lit, and 5 subjects, when the green light was seen to be lit, indicated the possibility of the second concealed light being lit or not ($\sim p.\cdot.q \vee \sim q$, $q.\cdot.p \vee \sim p$), i.e. indicated that they recognized the indeterminancy of the situation. The majority of subjects, in this experiment, responded as though employing material equivalence (if and only if p then q).[1] The tendency to interpret implication as material equivalence was confirmed in subsequent questioning of the children.

However, when the task was presented in a different manner and the subjects were asked to judge whether different combinations of the two lights were acceptable or not, a somewhat different picture emerged. 28 out of 30 subjects judged the p.q contingency correctly, 27 subjects judged the $\sim p.\sim q$ contingency correctly, 23 subjects judged the $\sim p.q$ contingency correctly, and 16subjects the $p.\sim q$ contingency correctly (i.e. they judged p.q, $\sim p.\sim q$, $\sim p.q$

L. A distinction will be drawn between 'material equivalence' and 'matching' later in this chapter, p. 152

contingencies acceptable and the ~~p.e~~ p.~q contingency unacceptable). This is much more in line with the results of Peel's older subjects mentioned above.

In a further experiment conducted by Matalon with 45 subjects aged between 6 years 4 months and 8 years 7 months, he utilized a 'more natural' situation. This consisted of a model of a village. The model had five houses, a post office, a church and a school, and leading from the village was the only road along which, the children were told, a man had to travel in order to reach the village from his home. Alongside the road leading to the village was a house. The children were told: 'If the man has been to the post office, then he has passed by the house'. They were then asked questions such as: 'The man has been to the post office, did he pass by the house?' and 'The man has passed by the house. Has he been to the post office?' The results indicated quite clearly that the majority of the children were utilizing material equivalence. A further group of questions, though, suggested otherwise. The children were asked questions about the possibility of different combinations of events occurring, e.g. 'Is it possible that he (i.e. the man) has passed by the house and that he has not been to the post office?' With such questions 43 of the 45 subjects responded correctly to the q.p contingency, 40 subjects responded correctly to the ~q.p contingency, 31 subjects responded correctly to the q.~p contingency and 18 subjects responded correctly to the ~q.~p contingency (i.e. they agreed that q.p, q.~p, ~q.~p were possible and denied that ~q.p was possible).

One interesting feature of these experiments was the type of explanation the children produced. In the 'red and green lights' experiment the children produced explanations based on the statement they were given, i.e. they referred to the red and/or green lights being lit or not. With the 'village' experiment though, explanations were based on the properties of the village and were not restricted to the information contained within the statement. For example, when asked if the man had been to the post office when he had not passed by the house, one subject replied: 'No ... he cannot go by another road'. Another subject when asked: 'The man has passed by the house. Has he been to the post office?' replied: 'He has been to the school ... perhaps he has been to the school, perhaps to the post office'. How far this type of explanation is a function of the younger ages of the 'village' children or how far it is a function of the nature of the 'village' experiment one cannot say.

Studies of the way adults handle implication are much more numerous than studies of children's handling of implication. Wason and his colleagues have conducted a series of experiments designed to investigate how implication is understood by adults. Early work (Wason 1966) revealed that when faced with a series of cards on one side of which was a letter and the other side a number (the cards were placed either side upwards) and asked to determine whether the experimenter was lying when he said: 'If a card has a vowel on one side then it has an even number

on the other side', a group of students tended to respond by selecting those cards displaying vowels and those cards displaying even numbers. A correct response would have been to select cards displaying vowels and cards displaying odd numbers, since only in these two cases (i.e. the modus ponens and the modus tollens) can one infer what should be on the reverse of the cards. Wason hypothesises, firstly, that his subjects have assumed three truth values for the conditional: true, false and irrelevant, and that vowels with even numbers verify, vowels with odd numbers falsify and consonants with any number are irrelevant. Wason's second hypothesis is that: '...the need to establish the "truth" of the statement predominates over the instruction'. Thus Wason's subjects incorrectly selected even numbers (i.e. affirmed the consequent) since even numbers were associated with vowels and were considered to verify the conditional. In addition they failed to select odd numbers (i.e. denied the contrapositive) since to do so 'the individual presumably makes a judgement of falsity by uttering a covert negative to himself' and 'we seldom use a proposition or judgement that something is false in order to make a deduction'. (Wason, 1968).

Wason (1968) attempted to elicit the contrapositive inference by two kinds of 'therapy'. In one experiment cards displaying, for example, D,3,B and 7 were shown to the subject who was told: 'If there is a D on one side of any card, there is a 3 on its other side'. The subjects (University students) had to select which of the four

cards would enable them to determine whether the statement was true or false. They then had to say what values, if any, on the reverse of the cards would make the statement false. Following this they had the opportunity to revise their initial selection of cards before assessing each card (by looking at the front and reverse of it) as true or false with respect to the statement. Wason's hypothesis that this procedure would facilitate the selection of $\wedge\bar{q}$ (i.e. the card displaying 7) was not confirmed. Again selection of cards displaying D and 3 (i.e. p and q) were most common both in the initial and revised selection. However, in the final assessment of each card Wason's theory that p.q is considered true, p.$\wedge$q false and $\wedge$p with either q or $\sim$q irrelevant was confirmed for p.q, p.$\wedge$q and $\wedge$p.$\wedge$q, but not for $\sim$p.q which the majority of subjects considered to be false.

The second type of 'therapy' and the second experiment was designed to make the subjects aware that the p.$\wedge$q contingency falsified the sentence, in the hope that the awareness that $\wedge$q is crucial for falsification would lead to its selection later. Again cards (this time with shapes on one side and scribble on the other) were used. The subjects were presented with a statement of the form: 'If there is a square on one side of the card, then there is a red scribble on the other side.' They were then presented with four cards corresponding to contingencies p.q, p.$\sim$q, $\wedge$p.q, $\wedge$p.$\wedge$q and asked to select 'the one card which makes the rule false' and then any cards which 'prove the rule true'. Without exception all the subjects selected

p.~q as the only falsifying contingency and p.q as the only verifying contingency. Next eight cards corresponding to contingencies p.q, p.~q, ~p.q, ~p.~q, q.p, q.~p, ~q.p and ~q.~p were placed in front of the subject face upwards and the subject had to select those cards which could show whether the rule was true or false. Again cards showing p and q were selected by the largest number of subjects, followed by selection of cards showing p only. Very few subjects selected cards showing ~q. However, when asked if any value on the reverse of ~q could make the rule false, the majority of subjects said p on the reverse of ~q would falsify.

Implication can be expressed in forms other than 'if p then q'. Wason and Johnson-Laird (1969) carried out an experiment in which implication was expressed in its disjunctive form (~p v q) and found that 52.1 per cent of their student subjects correctly selected p and ~q as the two cards whose reverse sides would prove the truth or falsity of the disjunctive statement. However, when the statement was in the form of a positive disjunction (i.e. p v q) the success rate was even higher (75 per cent) suggesting that negation contributes to some extent towards the difficulty of implication. A further experiment (Johnson-Laird and Tagart, 1969) examined implication expressed in four forms; 'if p, then q', 'there isn't p, if there isn't q', 'either there isn't p, or there is q (or both)' and 'there is never p without there being q'. The subjects task was to classify sets of stimuli into three categories: true, false and irrelevant with regard

to the statement. As in the previous experiment (Wason and Johnson-Laird, 1969) the disjunctive form of implication (either there isn't p, or there is q (or both)) produced a truth-functional analysis as the most frequent response (i.e. p.q true, p.~q false, ~p.q true and ~p.~q true). The three other statements produced responses in line with Wason's theory (i.e. p.q true, p.~q false, ~p.q and ~p.~q irrelevant).

Another group of experiments (Wason, 1964, 1969a; Wason and Johnson-Laird, 1970) indicate that sometimes it is possible to elicit correct responses from subjects who have previously reasoned fallaciously by facing the subject with contradictions and inconsistencies in his reasoning.

A group of experiments conducted by Legrenzi (1970) provides some support for Wason's theory, but one task designed as a 'strictly binary situation' produced results which contrasted with Wason's theory. In this task the experimenter rolled a ball-bearing down the inclined plane of a small billiard table. The ball-bearing rolled into one of two channels, one to the left and one to the right. In addition a green or a red lamp could be lit. The subjects were presented with three types of statement: 'If the ball rolls to the left, then the green lamp is lit', 'It is not possible for the ball to roll to the left and for the green lamp not to light'. and 'It is not possible for the ball to roll to the left and for the red lamp to light'. Four contingencies corresponding to the statement were presented (p.q, p.~q, ~p.q, ~p.~q) and

the subjects made judgements as to whether the contingencies followed, did not follow or were irrelevant to the statement. When the statement was in the form 'if..., then...' the majority of subjects judged p.q and $\wedge p.\wedge q$ to be true and $\wedge p.q$ and $p.\wedge q$ to be false, i.e. they appeared to be handling implication as material equivalence. The two other statements were handled in a truth-functional manner with p.q, $\wedge p.q$ and $\wedge p.\wedge q$ all true and $p.\wedge q$ false.

Another experiment by Taplin (1971) presented implication in the form of sentences such as: 'If food is constantly supplied to them, then the very fiercest creatures live peaceably together' and 'If Mrs. Elton is a snob, then Mrs. Bates is a bore'. Five types of contingency were examined p.q, $\wedge p.\wedge q$, q.p, $\wedge q.\wedge p$ and $p.\wedge q$. The subjects (university students) were required to say whether the consequent necessarily followed the antecedent. Twelve examples of each contingency were used. Taplin found that the most frequent response pattern was to affirm the consequent necessarily follows the antecedent for p.q, $\wedge p.\wedge q$, q.p and $\wedge q.\wedge p$ and deny that this was so for $p.\wedge q$.

The studies of implication which have been described raise two important points. Firstly it is clear that the nature of the task for example whether the subject is required to 'select' or 'evaluate' and the wording of the implication influence the type of result which is produced. Of particular importance is whether the nature of the task is or is not 'strictly binary'. A very relevant study conducted by Thompson (cited in Wason and Johnson-Laird, 1972) indicated that children as young as five responded to a

'strictly binary' situation according to material equivalence, but in a comparable non-binary situation this pattern was broken and replaced by a variety of responses.

Secondly, the results of experiments with adults throw some considerable doubt on Piaget's theory of formal operations suggesting that 'formal operations may be specific to the ingenious "concrete" tasks devised by Inhelder, but not processes which can be used to solve a novel problem'. (Wason, 1969b).

B. Experiment 4. Stars and Wee Animals

a. Introduction

In the preceding section, 'Introduction to implication' the way in which school-age children and adults handle implication was discussed. There was very little evidence to suggest in what manner pre-school children might be expected to respond in an implication task. This experiment is designed to attempt to look at pre-school children's handling of implication and to determine what kind of response or responses, if any, children of this age make.

Four small boxes were used in the experiment. On the lids of some of the boxes stars were positioned and inside some of the boxes small rubber animals (referred to as 'wee animals' because of the local dialect) were placed. When the boxes were closed the subject could see only the stars on the lids and not the contents of the boxes (i.e. the wee animals). When the boxes were open the subject could see the wee animals, but not the stars on the lids. Statements of the form: 'If there is a star on the box, then there is a wee animal in the box', were used in conjunction with the boxes in both their open and closed states and the subject was required to select those boxes on which, according to the statement, there was or might be a star (when the boxes were open) and those boxes in which, according to the statement, there was or might be a wee animal (when the boxes were closed).

In effect, the subject was presented with implication

in the form 'if p then q'. When the boxes were closed he had in front of him instances corresponding to p and ~p (i.e. the presence of absence of a star on each lid) from which he had to select those cases in which he thought q did or might follow (i.e. those boxes in which there was or might be a wee animal). When the boxes were open he was again presented with 'if p then q', but this time he had in front of him instances of q and ~q (i.e. the presence or absence of a wee animal in each box) and had to select those cases in which he thought p did or might follow (i.e. those boxes which had or might have a star on the lid).

In addition to presenting implication in its positive form, statements in which either p or q or both were negated, were included in the study. These afforded the opportunity of observing how implication would be handled in a 'more difficult' negative context.[1]

The four statements used in the experiment, therefore, were:

1. If there is a star on the box, then there is a wee animal in the box ($S \supset WA$).[2]
2. If there is a star on the box, then there is no wee animal in the box ($S \supset \overline{WA}$).

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1. See references to the difficulties of negation in Chapter II. Disjunction. (pp. 77, 91)
2. 'S' and 'WA' represent star and wee animal and are used for specific statements. 'p' and 'q' are used to symbolize the form of implication.

3. If there is no star on the box, then there is a wee animal in the box ($\overline{S} \supset WA$).
4. If there is no star on the box, then there is no wee animal in the box ($\overline{S} \supset \overline{WA}$).

The statements were used both with the boxes closed and the boxes open, thus putting the subject in a situation where he had to draw conclusions from p, $\sim p$, q and $\sim q$.

According to formal logic all contingencies in the task are true and valid. No false or invalid situations arise, therefore, the subject is not being asked to judge the truth or falsity of the statement, but merely to act on the statement and distinguish between those instances where necessity or possibility indicate the presence or possible presence of a star (or wee animal) and those cases where of necessity no star (or wee animal) can be present.

The selections which would be expected on the basis of a truth-functional analysis for each statement are given in Figure 3.

Figure 3

Selections based on a truth-functional analysis

Statement	Boxes closed		Boxes open	
	Select	Reject	Select	Reject
$S \supset WA$	S, $\overline{S}$	-	WA	$\overline{WA}$
$S \supset \overline{WA}$	$\overline{S}$	S	$\overline{WA}$	WA
$\overline{S} \supset WA$	S, $\overline{S}$	-	WA, $\overline{WA}$	-
$\overline{S} \supset \overline{WA}$	S	$\overline{S}$	WA, $\overline{WA}$	-

However, on the evidence discussed in the Introduction to this experiment, that neither school-age children nor adults conform to a truth-functional analysis of implication, it is unlikely that responses of the type set out in Figure 3 will be obtained from pre-school children. What is of more interest in this experiment is whether children of three to five years will make any kind of response which suggests that their behaviour is being guided by the information they gain from the implication statement and if so what form this behaviour takes.

b. Method

As in previous experiments in this study, the task was referred to as a game in which the subjects were asked to participate.

Since it is only through verbal explanation on the part of the subject that one can obtain knowledge of the subject's awareness, if any, of the necessity and possibility of his selections, it was decided once again to attempt to elicit justifications of selections from the subjects. On the grounds that the 'Why' questions occur earlier in a child's development than 'How' questions (Yamamoto, 1962) the children were asked: 'Why do you think there is/might be a wee animal/star in/on that box?' rather than 'How do you know....?' as in the earlier 'Houses and boxes' experiment.

Because of the evidence, described in the Introduction to this experiment, that adults do not handle implication in a truth-functional manner and because the manner in which adults do handle implication varies from task to

task it was decided to include an adult sample in this experiment in order to gain a 'standard' against which the children's responses could be compared. In addition a control group of children, who performed the task without receiving the statement, were used as a second 'standard'. Any difference in response pattern between the experimental children and the control children could thus be attributed to the implication statement.

i) Subjects

Experimental subjects: children

30 nursery school children (15 boys, 15 girls) aged between 3 years 1 month and 4 years 11 months. Mean age 4 years 1 month, median age 4 years 2½ months.

Control subjects: children

10 nursery school children (5 boys, 5 girls) aged between 3 years 2 months and 4 years 11 months. Mean age 4 years 2 months, median age 4 years 3 months.

Experimental subjects: adults

10 adults aged between 20 and 30 years (5 men, 5 women).

ii) Material

4 unpainted boxes, 2¼" x 2¼" x 2". The lids of the boxes were hinged and could either be closed or lifted into a vertical position.

2 red cardboard stars which could be attached to the lids of the boxes and which were in the subject's view when the lids were closed and out of his view when the lids were raised to a vertical position.

3 small rubber animals.

iii) Procedure

Experimental subjects: children

Each S was tested individually, seated at a low table. E placed the four boxes, in line, on the table in front of S and said: 'I have some boxes here. On some of the boxes there are stars like these (E indicated the stars on the lids of the boxes) and in some of the boxes there are wee animals like these' (E showed S the wee animals inside the boxes).

E then continued: 'Sometimes the boxes will be closed and you will be able to see the stars, but you won't be able to see the wee animals, like this (E shows S the boxes closed) and sometimes the boxes will be open and you will be able to see the wee animals, but you won't be able to see the stars, like this' (E shows S the boxes open).

E said: 'We are going to play a game with the boxes. This time the boxes are open/closed and you can see the wee animals/stars, but you can't see the stars/wee animals. I'm going to tell you something and then I want you to show me where there is/might be a star/wee animal. Listen carefully'.[1]

One of the following four statements was then made

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1. In the trials where, according to a truth-functional analysis of the statement, a star/wee animal was present of necessity 'is' was used. In the trials where the presence of a star/wee animal was only a possibility (i.e. in trials where no necessary conclusion could be drawn) 'might be' was used.

by E:

1. If there is a star on the box, then there is a wee animal in the box.
2. If there is a star on the box, then there is no wee animal in the box.
3. If there is no star on the box, then there is a wee animal in the box.
4. If there is no star on the box, then there is no wee animal in the box.[1]

If S made no response at this stage E said: 'Show me where there is/might be[2] a star/wee animal'. As S made his selection/s E moved the chosen box/es out of line away from S.

When S stopped selecting boxes E asked: 'Do you think there is/might be[3] a star/wee animal on/in any other box?' If S answered 'Yes' E asked: 'Where?' and selection of boxes continued.[4] If S answered: 'No' E pointed to each of the unselected boxes and asked in

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1. Where the word no was used it was stressed.
2. Using whichever expression (i.e. 'is' or 'might be') was used by E before the statement was presented.
3. If a 'necessary' box still remained unchosen by S 'is' was used. If only 'possible' boxes remained unchosen 'might be' was used.
4. In some cases S did not answer, 'Yes' but simply pointed at another unselected box, sometimes with an accompanying expression such as 'In there'.

turn: 'Do you think there is/might be a star/wee animal on/in this box?' In practice all Ss asked this question responded 'No'.

The procedure also allowed for 'Don't know' answers to be noted, but in practice these never occurred.

When selection was complete and S had denied that any remaining boxes could have a star on them or a wee animal in them E said: 'Listen carefully' and repeated the statement before pointing to each selected box in turn and asking: 'Why do you think there is/might[1] be a star/wee animal on/in that box?'[2]

After questioning the subjects were told: 'Open/close the box/es you have chosen and see whether the stars/wee animals are there'.

The experiment continued with E rearranging the stars and wee animals and placing the four boxes in front of S whilst saying: 'Now we're going to play the game again. This time the boxes are closed/open and you can see the stars/wee animals, but you can't see the wee animals/stars. I'm going to tell you something and then I want you to show me where there is/might be a wee animal/star. Listen

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1. 'Is' was used when the selection was made in response to a question or instruction containing the word 'is' and 'might be' was used when the selection was made in response to a question or instruction containing 'might be'.
2. Hindsight suggests that it might have been profitable to question children on the boxes they rejected also, but unfortunately such questioning was not carried out.

carefully'. The experiment then continued as described above.

Experimental subjects: adults

As in the 'Houses and boxes' experiment adult Ss were told that no trickery was involved and were asked for their serious co-operation in return for an explanation of the purpose of the experiment at the end of the trials. The adult version was modified only by omission of the reference to 'playing a game'. In all other respects the procedure was the same as for the children.

Control subjects: children

The procedure was the same as for the experimental children except that no justifications were requested and the statement used was: 'There is/might be[1] a wee animal/star in/on some of the boxes'.

iv) Design

The experiment was designed originally for 24 Ss aged between 3 years 1 month and 4 years 7 months (i.e. with ages corresponding to the ages of the Ss in the earlier 'Houses and boxes' and 'Disjunctive syllogism' experiments). However, during the course of testing it became apparent that children at the upper end of this age range (i.e. children over 4 years) were showing signs of a different response pattern from the younger children and, therefore, a further six older subjects were included bringing the upper age to 4 years 11 months. The

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1. 'Is' was used on half the trials, 'might be' on the other half of the trials.

design as it is described here is for 24 Ss. The way in which the six additional subjects were incorporated into the study will be described later.

Each of 24 Ss was assigned to one of 24 orders produced by permutation of the four statements. For each statement there were two conditions (i.e. boxes open, boxes closed). This gave 8 statement/condition combinations and so each S's order was repeated twice to give 8 trials per S (i.e. one trial for each statement/condition combination). The trials were given in two separate sessions of 4 trials each. The 'boxes open' and 'boxes closed' conditions were alternated in each S's trials. Half the Ss in each session commenced the session with the 'boxes open' condition and half with the 'boxes closed' condition. Each S commenced the two sessions with a different condition.

For the group of 24 Ss as a whole each statement occurred 48 times (6 times in each trial position) and each statement/condition combination occurred 24 times (3 times in each trial position).

Two boxes out of the four always had stars on them. The 6 possible combinations of two boxes with stars on them were distributed equally throughout the trials. Each combination occurred 32 times (16 times in the 'boxes closed' conditions, 16 times in the 'boxes open' condition). Each S had each combination at least once and not more than twice.

Having stars on two of the four boxes meant, according to a truth-functional analysis, that the conclusion which

could be drawn from two of the boxes was a necessary one and the conclusion drawn from the other two boxes was a possible one. From statements 'S⊃WA' and'$\overline{S}$⊃WA' it necessarily follows that two of the boxes contain wee animals. From statements 'S⊃$\overline{WA}$' and '$\overline{S}$⊃$\overline{WA}$' it necessarily follows that two of the boxes do not contain wee animals. For all four statements there are two boxes which possibly contain wee animals. Whenever, of necessity, wee animals had to be in two boxes, wee animals were placed in these boxes. Whenever, of necessity, wee animals had not to be in two of the boxes, these boxes were left empty. Whenever it was possible for wee animals to be in two of the boxes, a wee animal was placed in one box and the other box was left empty. This meant that for statements 'S⊃WA' and '$\overline{S}$⊃WA' three wee animals were used and for statements 'S⊃$\overline{WA}$' and '$\overline{S}$⊃$\overline{WA}$' one wee animal was used.

The 6 Ss, included in the study after the testing had begun, were allocated to 6 of the series of 8 trials used with the originally selected group of 24 Ss. They were allocated in such a way that for the 6 subjects each statement occurred at least once and no more than twice in each trial position and 3 Ss commenced with a 'boxes closed' condition and 3 Ss with a 'boxes open' condition.

The 10 adult Ss were similarly allocated to 10 series of 8 trials used with the originally selected group. These series were selected so that each statement occurred at least twice and no more than three times in each trial position and 5 Ss commenced with a 'boxes closed' condition and 5 Ss with a 'boxes open' condition.

The control children had only one session of 4 trials. The positions of stars and wee animals on and in the boxes, for all 10 control Ss, were the same as in one of the sessions presented to one of the experimental children. The positions used were selected to avoid the red stars being on two adjacent end boxes (i.e. on boxes 1 and 2 or on boxes 3 and 4) since two possible response patterns were an 'end-to-end search strategy or selection of starred boxes and stars in two adjacent end positions would have prevented a distinction being made between these two responses. In addition in two of the trials the boxes contained three wee animals (once with the boxes closed and once with the boxes open) and in two of the trials the boxes contained one wee animal (once with the boxes closed and once with the boxes open). Again end positions were avoided when there was one wee animal and three adjacent end positions were avoided when there were three wee animals (the positions for the three wee animals were boxes 1, 2 and 4 and boxes 1, 3 and 4).[1] In two trials the boxes were closed and in two trials the boxes were open. For one trial with the boxes closed and one trial with the boxes open, the statement was: 'There is a wee animal/star in/on some of the boxes'. For the other two trials (once with the boxes closed, once with them open) the statement was: 'There might be a wee animal/star in/on some of the boxes'.

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1. 1 is the left-most box and 4 the right-most box.

c. Results

Five types of response were identified. These are described here, before their frequency for different statements and conditions and their frequency in different age groups is given.

A. End-to-end search. Here the subject selected either the left-most box or the right-most box and continued selecting adjacent boxes until all four boxes had been selected. Occasionally he stopped after one or two selections, but always, when asked whether there was/might be a star/wee animal on/in any other box, he continued selecting adjacent boxes until the opposite end of the array was reached.

B. Four box selection with p and $\sim$p or q and $\sim$q differentiated. Here the subject selected all four boxes, but selected those with stars or wee animals first followed by those with no stars or no wee animals. Less frequently those without stars or wee animals were selected first followed by those with stars or wee animals. Again selection sometimes stopped after boxes with stars or wee animals (or boxes with no stars or no wee animals) had been chosen, but selection always continued when the experimenter asked whether there was/might be a star/wee animal on/in any other box.

C. Matching of star to wee animal and no star to no wee animal. Here the subject selected only those boxes which had a star when the boxes were closed and those boxes which had a wee animal when the boxes were open.

D. Equivalence. Here the subject produced material equivalence responses, i.e. the subject indicated that q followed p, but did not follow ~p and that p followed q, but did not follow ~q. Clearly for two statements, ('S⊃WA' and '$\overline{S}\supset\overline{WA}$'), this response is indistinguishable from response C ('matching'). This will be referred to later in the discussion of this experiment.

E. Part negation. This response was peculiar to the doubly negated statement '$\overline{S}\supset\overline{WA}$'. The subject selected the boxes without stars or without wee animals and rejected boxes with stars or with wee animals.

Very few responses (16 out of 240) were not classifiable into one of the above response categories.

The frequencies of these five responses for each statement/condition are given in Table 14.

Table 14

Frequencies of the five responses for each statement/condition

Response	Boxes closed				Boxes open				All statements/ conditions	
	S⊃WA	S⊃$\overline{WA}$	$\overline{S}$⊃WA	$\overline{S}$⊃$\overline{WA}$	S⊃WA	S⊃$\overline{WA}$	$\overline{S}$⊃WA	$\overline{S}$⊃$\overline{WA}$		
A	5	5	7	2	4	8	6	6	43	
B	7	4	3	6	2	5	2	5	34	
C	17[1]	8	8	9	21	6	20	9	42	56
D		12	10			8	-		30	
E	-	-	-	11	-	-	-	8	19	
Other response	1	1	2	2	3	3	2	2	16	
Total	30	30	30	30	30	30	30	30	240	

1. Here the response could be either 'matching' (i.e. response C) or equivalence (i.e. response D).

Two features of Table 14 are of interest. Firstly the fact that some subjects produce 'equivalence' responses to statements '$S \supset \overline{WA}$' and '$\overline{S} \supset WA$' suggests that some, at least, of the responses which are classified as either 'matching'[1] or 'equivalence' responses are probably 'equivalence' responses. It will be noted from Table 15 that there is a marked difference in the frequency of 'equivalence' responses between the younger and older half of the subjects. This difference is significant ($p<.01$). It is, therefore, hypothesized that for statement '$S \supset WA$' the younger subjects are probably producing 'matching' responses and the older subjects are probably producing 'equivalence' responses. However, it is not unreasonable to assume that statement '$S \supset WA$' is the easiest statement to handle and, therefore, there may be a larger number of 'equivalence' responses even from the younger subjects for this statement than for other statements.

With statement '$\overline{S} \supset \overline{WA}$' a different state of affairs exists. Comparatively few of the responses fall into either the 'matching' or 'equivalence' categories. The older subjects make type E responses where they select the 'no star' or 'no wee animal' boxes and reject the 'star' or 'wee animal' boxes. It is mainly younger subjects who produce the 'matching'/'equivalence' responses and it is, therefore, suggested that these responses are 'matching' responses whilst the older subjects, who produce 'equivalence' responses for other statements, make type E responses for statement '$\overline{S} \supset \overline{WA}$'.

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1. A fuller discussion of what constitutes a 'matching' response is given in the discussion of this experiment.

The second feature of Table 14 is the complete absence of 'equivalence' responses for statement '$\overline{S} \supset WA$', when the boxes are open, with a corresponding marked increase in the number of 'matching' responses when compared with other statement/conditions. An explanation for this phenomenon will be attempted in the discussion of this experiment.

An analysis of the results of individual subjects reveals that in only one case does a subject consistently produce the same response for each statement. One subject made 'end-to-end' responses (response A) for all statements. However, there was some consistency between the over all statements response patterns of some subjects. For example six subjects all produced 'matching'/'equivalence' responses for statement '$S \supset WA$', 'equivalence' responses for statement '$S \supset \overline{WA}$' and statement '$\overline{S} \supset WA$' (when the boxes were closed), 'matching' responses for statement '$\overline{S} \supset WA$' (when the boxes were open) and 'part negation' responses (i.e. response E) for statement '$\overline{S} \supset \overline{WA}$'. All these subjects were aged 4 years 6 months and over. In addition eight subjects always produced 'matching'/'equivalence' responses for statement '$S \supset WA$' although their responses to other statements varied.

Clearly one has to allow for inconsistency of response in children of this age and particularly from the younger half of the group (this was also the case in the 'Houses and boxes' experiment), but the evidence mentioned above suggests that some of the inconsistency is a function of differing degrees of difficulty of the statement.

Table 15 shows how the frequencies of the five responses varied with age.

Table 15

Frequencies of the five responses according to age

Response	Age				Total	
	3.1 - 4.2[1]		4.3 - 4.11			
A	31		12		43	
B	22		12		34	
C	24	28[2]	18	28	42	56
D	7		23		30	
E	3		16		19	
Other responses	5		11		16	
Total	120		120		240	

There is a significant difference ($p<.001$) between the response frequencies of the older and younger subjects in this study. This takes the form of a significant decrease with age ($p<.001$) of type A and type B responses and a significant increase with age ($p<.001$) of type D and type E responses. Type C responses ('matching' responses) also decline slightly with age, but it is suggested that this decline is more marked than it appears since some of the responses which are either

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1. There were fifteen subjects in each age range. The mean ages of the two age ranges were 3.7 and 4.7. The median ages were 3.7 and 4.6½.
2. Here the responses could be either 'matching' (i.e. response C) or 'equivalence' (i.e. response D).

'matching' or 'equivalence' responses are probably 'matching' responses for younger children and 'equivalence' responses for older children (see above).

Experimental subjects: adults

With the exception of four responses the adult subjects appeared to be employing material equivalence. Three of these exceptions came with statement '$\overline{S} \supset \overline{WA}$' where two of the adult subjects produced type E responses (i.e. they selected the boxes without stars/wee animals and rejected the boxes with stars/wee animals). The other exception is particularly interesting. It came with statement 'S⊃WA' when the boxes were closed. The subject first selected both starred boxes, but when asked if there might be a wee animal in any other box she hesitated for quite a while before saying 'May be ... you haven't said there isn't an animal there, have you?' Clearly this subject had gained some kind of insight into the situation. It is interesting to note that this subject was a primary school teacher and was probably the most intellectually able of the adult subjects. Unfortunately, though, the trial in which this occurred was the last in her series of eight trials. How far she would have employed this 'insight' with other statements later on is not known.

One noticeable feature of the way adults responded was that, when there was a negative statement, they tended to repeat the statement out aloud, often two or more times, and then to verbalize the conclusion they drew. For example for statement '$\overline{S} \supset WA$' with the boxes closed one subject

said: 'If there's not a star then there is a wee animal ... if there's not a star ... just a minute ... if there's not a star ... that means there's a star when the box is empty'.

Control subjects: children

37 of the 40 responses made by the control children involved selection of all four boxes. 32 of these responses were 'end-to-end' search strategies (18 in a left to right direction, 14 in a right to left direction), 2 of these responses were selection of boxes with stars or wee animals followed by selection of boxes with no stars or wee animals and three of these responses were apparently random. Of the three responses where not all boxes were selected, one was the selection of starred boxes only, one was the selection of one of the two starred boxes only and one was the selection of one box containing no wee animal.

Justifications

Justifications of responses in this experiment were much more easily obtained than in the previous 'Houses and boxes experiment'. Again some of the youngest children did not justify or justified: ''Cos it is', 'It's in there'. However, the majority of children produced one of three types of justification. Firstly justifications such as ''Cos it's got a star on it', ''Cos there's a wee animal', ''Cos there's a star' were quite widespread throughout all age ranges and with all response types. The second type of justification links the presence of stars with the presence of wee animals, 'When the star's

there, there's a wee animal there too', 'When there's a star there's a wee animal and when there's no star there's no wee animal, see'. This second kind of justification occurred in children from 3 years 8 months upwards. The third type of justification occurs only with older subjects who produce evidence of 'equivalence' responses. Here not only are negatives, which are not just a matching of no star to no wee animal, included in the justifications, but expressions such as: 'It's got to be', 'It must be', 'It's supposed to be', all of which indicate some awareness of necessity, occurred quite frequently.[1] For example: 'It's got to be in that box 'cos there's a star on it', 'When there's no star, there's supposed to be a wee animal in the box', 'It must be in there (pointing to the unstarred box) if it's not in there (for statement 'S⊃$\overline{WA}$' with boxes closed), 'The star's supposed to be there 'cos it's got a wee animal and when there's a wee animal there's supposed to be a star'(for statement 'S⊃WA' boxes open).

This latter type of justification is very similar to, if slightly less elegant than, many of the justifications produced by adults. For example: 'If there's no star then there should be a wee animal'. 'Well if there's no wee animal when there's a star there must be a wee animal when there is no star'. 'From what you said, the wee animals should be in boxes with stars on top'.

In some of the responses stars or wee animals were

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1. Reference to similar responses is made on p. 169

not found on or in all the boxes selected. The majority of subjects did not remark on this, possibly because the presence of a star or wee animal on or in some of the selected boxes was sufficient for the state of affairs not to be queried. However three subjects (one child and two adults) did comment on the absence of stars or wee animals. The child was one of the older subjects who produced 'equivalence' responses. He said: 'The wee animal's not there' when responding to statement '$S \supset \overline{WA}$', boxes closed, and he found a wee animal in only one of the two unstarred boxes he had selected. The experimenter asked him whether there should be a wee animal in the empty box and he replied emphatically 'Yes'. One of the adult subjects said: 'I only get one this time do I?' when he found only one of the two boxes he selected in response to '$\overline{S} \supset \overline{WA}$', boxes closed, contained a wee animal and the other adult made a point of indicating each time a star or wee animal was not present in his selections, apparently considering that this was part of the response he was expected to make.

d. **Discussion**

Five different types of response have been found in this experiment. One of these, the end-to-end search strategy, found with both experimental and control subjects, was also found with control subjects in the 'Houses and boxes' experiment. Its presence in the experimental responses here suggests that such responses were not guided by the implication statement at all.

The second type of response (i.e. the four box selection, with p and $\wedge$p or q and $\wedge$q differentiated) appears to be a response intermediate between the 'end-to-end' response and a 'matching' response. Clearly some significance is attributed to the presence or absence of stars and wee animals and the fact that this response occurred only twice in forty control responses indicates that the experimental statements play some part in eliciting it. A similar finding has been noted by Donaldson and Young (personal communication and reported in Donaldson and Wales, 1969b) with children aged three to five years. In their task two pictures of strings of four beads were displayed before the subject. The pictures were identical except that one picture had four red beads and the other picture had three red beads and one green bead. A string of beads was suspended between the two pictures with each bead covered in aluminium foil. The subject's task was to select the bead which had to be uncovered in order to say which of the two pictures was a picture of the string of beads. Donaldson and Young found their subjects, even after they had located the 'critical' bead and correctly identified the picture, still said that it was necessary to uncover more beads in order to know which picture was really the right one. Donaldson and Young suggest a possible reason for this is that the attractiveness of the task (i.e. unwrapping the beads) was such that the desire to carry on with this

activity took precedence over the production of an economical solution.[1]

The explanation suggested by Donaldson and Young could account for the type B responses in this experiment. Other explanations, though, are also possible. The differentiation made between p and ~p or q and ~q could reflect degrees of 'sureness', the subject being more sure of the correctness of his first group of responses than of his second group of responses, but in neither case responding with any certainty. Alternatively the subject may have forgotten the statement by the time he has finished selecting his first group of boxes and so reverts to the strategy of opening all the boxes. In some of these responses selection sometimes stopped after one group of boxes had been chosen. When this happened the experimenter asked whether there was/might be a star/wee animal on/in any other box. The subject then continued selecting boxes. Perhaps the intervention of this statement was taken by the subjects to be an indication that further selections were required.

The type B responses can be grouped into those in which stars or wee animals were selected first and those in which boxes without stars or wee animals were selected first. The latter were far less frequent. It was thought that selection of boxes without stars or wee animals first might be related to the presence of negatives in the

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1. It is also interesting to note that Donaldson and Young found frequent 'end-to-end' search strategies, this time in the form of a consistent top-to-bottom search of the string of beads, although the 'critical' bead was next to the bottom on the string.

statement, but this was not the case. These selections, however, were more frequent when the boxes were open than when they were closed. Why this is so is not clear.

According to a truth-functional analysis of implication, selection of all four boxes is a 'correct' response for four of the statement/conditions ('S>WA', $\overline{S}$>WA' boxes closed and '$\overline{S}$>WA' and '$\overline{S}$>$\overline{WA}$' boxes open). However, four box selection (either 'end-to-end' or 'differentiation of p and $\sim$p and q and $\sim$q) made by the experimental subjects were not restricted to any specific statements and can, therefore, be taken to be independent of truth-functional analysis.

The 'matching' responses in this experiment suggest a number of possible explanations. The subject may be responding independently of the statement and simply selecting boxes which are distinguished by the presence of a star or a wee animal. Alternatively, the subject, again acting independently of the statement, may be assuming a correspondence between the presence of one attribute (i.e. star or wee animal) and the presence of the other attribute and between the absence of one attribute and the absence of the other attribute. However, the infrequency of 'matching' responses in the control group (only one such response was noted) raises problems for these two explanations and indicates that the experimental statement is in some way instrumental in 'matching' responses. A further explanation is, therefore, suggested. This is that the subjects who produce 'matching' responses ignore the negatives in the statements, possibly because

'no star' or 'no wee animal' is not a physically present attribute visible to the subject and possibly because other difficulties of negatives in this task are so great that the subject is not capable of handling them. The statements are thus treated as positive statements and are interpreted, by the subject, to mean that a relationship exists between the presence of a star and the presence of a wee animal. Many of the justifications from subjects producing 'matching' responses indicate an awareness of such a relationship, for example: 'Because there's a star and when there's a star there's a wee animal in the box and when there's no star there's no wee animal in the box'. How far these subjects consider the relationship to be based on necessity and how close such a response is to an 'equivalence' response is difficult to say. Certainly subjects who produced 'matching' responses did not ever utilize modal expressions such as 'must', 'has to be' in their justifications.

Olson (1966) conducted an experiment in which three, five, seven and nine-year-old children had to determine which of several patterns was 'correct' by pressing bulbs which lit up when they corresponded with the 'correct' pattern (see p. 105). He found that around age five his subjects produced what he described as a 'successive pattern matching strategy' in which they pressed bulbs corresponding to each pattern in turn, regardless of whether these bulbs were informative (i.e. whether they were common to more than one pattern and therefore of no use in discriminating between patterns or whether they

were peculiar to one pattern and therefore a means of discriminating between patterns). Olson's task is different from the one employed here since it involves no verbal statement containing information on which the subject can act. Instead the information the subject used is contained within the visual display. However, the 'successive pattern matching strategy' employed by Olson's five-year-olds is similar to the 'matching' responses noted here in that aspects of the task which are made distinctive (the patterns in Olson's task and the stars and wee animals in this experiment) are selected by the subjects irrespective of their appropriateness in the task the subject is asked to perform.

It should perhaps be noted here that the subjects who employed the 'successive pattern matching strategy' in Olson's experiment were slightly older than the subjects in this experiment. Olson's younger subjects utilized a strategy corresponding to the 'end-to-end' search found in the experimental and, most markedly, in the control groups in this experiment. Perhaps, if the control task used here, had been presented to older subjects a type of 'matching' response would have emerged based on either selection of the most distinctive aspects of the display or the assumption that the presence of one attribute coincided with the presence of the other attribute and the absence of one attribute coincided with the absence of the other attribute.

It is possible that 'matching' responses found in this experiment are more a function of the design of the

experiment than a function of implication statements. The statements may have served merely to alert the subject to the need to make some kind of discrimination between boxes with attributes and those without (a discrimination which, on the basis of Olson's findings, may have been made without any statement by older subjects). The use of the presence and absence of stars and wee animals to represent p, $\sim$p, q and $\sim$q may then have been a sufficient condition for the subjects to assume, independently of the statement, that the presence of one attribute indicated the presence of the other attribute and the absence of one attribute indicated the absence of the other attribute.

The experiments of Matalon (1962) and Peel (1967) reported evidence of the handling of implication as though it were material equivalence by children of five years upwards (see p. 116). However, in Peel's experiment and in one of Matalon's experiments 'equivalence' responses were responses which required selection of like attributes. For Peel these were red beads with red counters and non-red beads with non-red counters and for Matalon they were a light which was lit with another light which was lit and a light which was not lit with another light that was not lit. Matalon points out that, from his findings, one cannot tell whether children normally handle implication as equivalence or whether the equivalence responses he obtained were attributable to the task he used.

Clearly a distinction can be made between a simple 'matching' of like attributes and an 'equivalence' response

(if and only if p then q) based on the drawing of a conclusion from a verbally presented premiss. In practice the behaviour resulting from these two procedures can be indistinguishable. In this experiment the inclusion of negatives in some statements provided some measure of distinction since 'equivalence' responses to statements '$S \supset \overline{WA}$' and '$\overline{S} \supset WA$' required the subject to go against a 'matching' response. However, negatives produce considerable difficulties in their own right and the extent to which the responses in this experiment have been influenced by these difficulties is unclear.[1]

Responses which are clearly based on equivalence (i.e. responses in which negatives are taken into account) occur mainly amongst the older children and adults. With six of the older children and the adults such responses are accompanied by justifications which include such expressions as 'must be', 'has to be'. As far as one can see these six children appear to be producing adult-type responses although the oldest child is only four years eleven months.

However, not all statements including negatives are handled even by the older children (and in some cases not by adults) according to material equivalence. The double negative statement, '$\overline{S} \supset \overline{WA}$', is handled by the older children and by two of the adult subjects in a way which suggests that only one of the negatives is taken into account. Rather than selecting boxes with stars and

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1. In the experiment that follows an attempt has been made to present a situation which does not include negatives and is not amenable to the matching of like attributes.

rejecting those without stars when the boxes were closed (or selecting boxes with wee animals and rejecting those without wee animals when the boxes were open), which is an equivalence response, these subjects selected boxes without stars and without wee animals and rejected boxes with stars and with wee animals. In addition no child ever handled the negative in statement '$\overline{S}$>WA' when the boxes were open although all adults produce equivalence responses for this statement/condition. Presumably the double negative statement and statement '$\overline{S}$>WA', boxes open, are intrinsically more difficult to manipulate than other statement/conditions in this study. The cancelling effect in which two negatives give a positive conclusion is probably quite alien to the experience of most children and it is, therefore, likely that the presence of two negatives in a statement merely serves to emphasize the negative quality of the statement and leads to the selection of unstarred boxes or boxes with no wee animals.

An analysis of the statement containing one negative suggests that they are of unequal difficulty in terms of the 'operations' required for an equivalence response. For example when the boxes are closed statement '$\overline{S}$>WA' simply requires the subject to follow the statement and select the unstarred boxes. When the boxes are closed statement 'S>$\overline{WA}$', on the other hand, requires the subject to draw the inference that the wee animal is in the unstarred box, i.e. he has to direct his attention to the boxes not mentioned in the statement, before he makes

his selection. When the boxes are open, however, the subject has to reverse the direction of the information given to him in the statement (i.e. from p⊃q he infers q∴p) so that he can select from boxes with and without wee animals. For statement 'S⊃$\overline{WA}$' this gives him '$\overline{WA}$∴S' which is a conclusion on which he can act directly by selecting boxes containing no wee animals. However, with statement '$\overline{S}$⊃WA' when the boxes are open the subject is required not only to reverse the direction of the information i.e. 'WA∴$\overline{S}$', but he is also required to make a further inference in order to draw a second conclusion, '$\overline{WA}$∴S', i.e. turn his attention to the boxes not mentioned in the statement, on the basis of which he makes his selection. Clearly these two operations need not occur in this order since the reversal of information could be the final operation preceding selection rather than the first operation. Clearly also the analysis of equivalence responses into separate operations is highly speculative, but such an analysis does indicate that statement '$\overline{S}$⊃WA', boxes open, may be more complex than other statement/conditions and provides a possible explanation for the absence of equivalence responses for this statement/condition. The pre-selection operations required for equivalence responses for the single negative statement/conditions are given in Figure 4.

Figure 4

Pre-selection operations required for single-negative statement/conditions

Operation	Boxes closed		Boxes open	
	$S \supset \overline{WA}$	$\overline{S} \supset WA$	$S \supset \overline{WA}$	$\overline{S} \supset WA$
Turn attention to non-mentioned boxes	+	-	-	+
Reverse direction of information	-	-	+	+

We can perhaps now look at the high proportion of 'equivalence' responses with adults. Certainly such responses conflict markedly with Piaget's theory of formal operations, on the basis of which one would expect a truth-functional treatment of implication from adult subjects. The results found here agree with those noted by Legrenzi (1970) who found equivalence responses to statements of the form 'if..., then...' in a situation which is similar to the present experiment in that it is 'strictly binary', i.e. a situation 'in which the alternatives are both the only two possibilities which can occur, and, in addition, mutually exclusive' (Legrenzi, 1970).

At first glance the findings of this experiment appear to be at odds with those reported by Wason (see p. 119). However, if we take into account the nature of the tasks Wason's subjects were asked to perform and the task employed in this experiment we find that much of the disparity can be resolved. In this experiment the subject was presented with a conditional statement of the form 'if p, then q' and faced with instances corresponding to

p, ~p, q and ~q. He was then required to select those instances where p or q possibly or necessarily followed and to reject those instances where it was impossible for p or q to follow. Clearly this task is very different from Wason's 'selection' procedure where the subject was required to select instances where the truth or falsity of the conditional could be judged from whatever followed. The present experiment is perhaps more akin to Wason's 'evaluation' procedure in which the subject is required to judge contingencies such as p.q, ~p.q, q.p and~q.p as true, false or irrelevant with respect to the conditional. In this task the subject is asked whether q can follow p and ~p and whether p can follow q and ~q, a task which comes very close to evaluating contingencies as in the Wason procedure, but in which there is a major difference in that the subject does not have open to him an 'irrelevant' category. The very nature of the task precludes the subject from utilizing such a category and forces him into using a true/false division.

It can be said that subjects in Wason's experiments and the subjects in this experiment are operating under markedly different constraints and that these constraints go a long way towards explaining why, for example, Wason's colleagues Johnson-Laird and Tagart (1969) obtained judgements of irrelevancy for contingency ~p.q whilst in this experiment the possibility of q following ~p and the possibility of p following ~q was denied. However it should be noted that in some circumstances Wason has found contingency ~p.q to be judged false and for subjects

to say that p following $\wedge q$ would falsify a conditional (Wason, 1968).

Legrenzi (1970) puts forward an interesting hypothesis which may be relevant to the 'equivalence' responses found in this experiment. In referring to an unpublished study by Mazzocco he points out that 'one condition which leads to the converse of a rule being accepted is when it simplifies a cognitive task'. Certainly to handle implication as equivalence rather than to subject it to a truth-functional analysis appears to be simplifying the task and it may be that avoidance of difficulty has contributed to the responses obtained in this experiment.

Finally, in this experiment, justifications were more easily obtained from the subjects than in the earlier 'Houses and boxes' experiment. These justifications were frequently not indicative of reasoning, but at least some verbal explanations were attempted by the subjects. There are two possible reasons for this. Firstly questions preceded by 'Why' may be more easily handled by children of this age than questions preceded by 'How', and secondly this task or implication may be more amenable to justification than the earlier task or disjunction.[1]

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1. Further discussion of points raised in this experiment, e.g. the 'inferential' nature of the children's responses and a possible developmental sequence, will be made in Chapter V. Discussion.

C. Experiment 5. Ball, Brick and Cards

a. Introduction

In this experiment an attempt has been made to look at implication using material which is not amenable to the 'matching' of attributes as in the previous experiment, 'Stars and wee animals', where one could not determine whether the 'matching' of stars and wee animals was a function of attributes present and attributes absent or a function of the conditional statement.

The experiment is in two parts. In the first part, on the basis of a conditional statement of the form 'if p, then q', the subject is required to select from instances corresponding to q and $\sim$q whatever he thinks should follow p and $\sim$p. In the second part of the experiment, again on the basis of a conditional statement of the form 'if p, then q', he is asked to judge the acceptability or non-acceptability of contingencies p.q, p.$\sim$q, $\sim$p.q, $\sim$p.$\sim$q. This second part of the experiment was included in order to gain wider coverage of the area than one would gain from the subjects' selections alone.

b. Method

A ball and brick were used to represent p and $\sim$p and two cards, one red and one white, were used to represent q and $\sim$q. In the trials in which the subject draws a conclusion from p or $\sim$p (these will be referred to as the 'S drawing conclusion' trials) either the brick or the ball was placed in front of the subject, following

which the experimenter presented him with a conditional statement such as: 'If there is a brick, then there is a white card'. For this statement a brick in front of the subject would mean that he had to draw a conclusion from p and a ball in front of the subject would mean that he had to draw a conclusion from $\sim$p. The subject was then required to select from the red and white cards (i.e. q and $\sim$q) whichever card he thought was appropriate. In the second group of trials (which will be referred to as the 'S judging E's conclusion' trials) a similar procedure was followed except that the experimenter made the selection from the red and white cards and the subject was required to judge whether the experimenter's selection was 'all right' or whether it was 'wrong'. The expressions 'all right' and 'wrong' were chosen as expressions which were understood by the children in pilot testing.

As in previous experiments ('Houses and boxes' and 'Disjunctive syllogism'), where the ability to identify colours was a necessary, but task-extraneous, variable of the experiment, the experiment was preceded by a colour identification task. This also included identification of the ball and brick, since the ability to discriminate between the two was also task extraneous, but essential to the experiment. Immediately preceding the experiment the experimenter placed the ball, the brick and the red and white cards on the table in front of the children whilst saying: 'I've got a ball, a brick and some cards here'. The experimenter then pointed to each object in

turn and asked: 'What is this?' If a child said; 'A card' when a card was pointed out, the experimenter asked: 'What colour is it?' After the subject had identified each object the experimenter asked him to: 'Show me the ball'(the brick, the white card, the red card) going through each object in turn. If a child failed to respond or responded incorrectly at any stage in this identification procedure, it was proposed not to use him as a subject, but to substitute another subject of a similar age in his place. In practice this was not necessary since all subjects selected performed this pre-experimental test correctly.

In additon to the children, a group of adults also performed the task (see reference to adult subjects on p. 55).

i) Subjects

Children

24 nursery school children (12 boys, 12 girls) aged between 3 years 2 months and 4 years 11 months. Mean age 4 years 1½ months, median age 4 years 2 months.

Adults

8 adults aged between 20 and 30 years (4 men, 4 women).

ii) Material

A ball, diameter 1¼"; a brick, sides 1"; a red card and a white card, 3" x 2½".

iii) Procedure

'S drawing conclusion' trials

Each S was tested individually, seated at a low table

facing E. E said to S: 'I've got a ball, a brick, a red card and a white card. (E showed the four objects to S). We are going to play a game with them and in this game I'll put the ball or the brick there (E indicated a position on the table in front of S) and you have to put a card there (E indicated a second position adjacent to the first position and handed the cards to S). E continued: 'This time I'm going to put the ball/brick there (E positioned ball/brick in front of S). Now listen carefully to what I say'. E then presented the conditional statement: 'If there is a ball/brick, then there is a red/white card'. If S did not place either the red or white card next to the ball/brick E asked: 'What are you going to put there?' After S had selected a card E asked: 'Why is the red/white card supposed[1] to be there?' After this E said: 'Now we'll play the game again'. E handed the cards to S and the procedure was repeated from the point where E says: 'This time I'm going to put the ball/brick there'.

'S judging E's conclusion' trials

After showing S the four objects E said: 'We are going to play a game with them (i.e. the four objects) and in this game I'll put the ball or the brick there (E indicated a position on the table in front of S) and then I'm going to put a card there (E indicated a second position adjacent to the first position), but sometimes

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1. The word 'supposed' was used since it had occurred quite frequently in justifications obtained in the 'Stars and wee animals' experiment.

I'll put a card there that's wrong and sometimes it will be all right. This time I'm going to put the ball/brick there (E positioned the ball/brick in front of S). Now listen carefully to what I say'. E then presented the conditional statement and said: 'I'm going to put the red/white card there'(E positioned the red or white card next to the ball/brick). E then asked: 'Is the card all right or is it wrong?' When S had responded E asked: 'Why is it all right/wrong?' After this E said: 'Now we'll play the game again' and the procedure was repeated from the point where E says: 'This time I'm going to put the ball/brick there'.

Adult subjects

Adult Ss were told that no trickery was involved and were asked for their serious co-operation in return for an explanation of the purpose of the experiment at the end of the trials. In addition no reference to 'playing a game' was made with adult Ss.

iv) Design

In the 'S drawing conclusion' trials the ball/brick[1] represented either p or $\wedge$p. This gave two conditions. In addition the statement could involve four combinations of ball/brick and red card/white card (i.e. Ball$\supset$red card, ball$\supset$white card, brick$\supset$red card, brick$\supset$white card). Therefore each S was presented with all four statement variations for each condition. This gave eight trials per S. The two conditions were alternated for each S, with half the Ss commencing with the ball/brick referring to p and half with the ball/brick indicating $\wedge$p.

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1. This is the ball/brick placed in front of the subject.

For the 24 Ss each condition occurred 96 times, 12 times in each trial position. For the 24 Ss each statement variation occurred 48 times, 6 times in each trial position and each condition/statement variation combination occurred 24 times, 3 times in each trial position.

In the 'S judging E's conclusion' trials there were four conditions representing contingencies p.q, p.~q, ~p.q and ~p.~q. Again there were also four statement variations used with each condition giving 16 trials per S. Each S was assigned to one of the 24 orders resulting from permutation of the four conditions.

For the 24 Ss each condition occurred 96 times, 6 times in each trial position. For the 24 Ss each statement variation occurred 96 times, 6 times in each trial position and each condition/statement variation combination occurred 24 times, at least once and no more than twice in each trial position.

The 'S drawing conclusion' trials were conducted in one session, the 'S judging E's conclusion' trials were conducted in two sessions. Half the subjects commenced with the 'S drawing conclusion' trials and half commenced with the 'S judging E's conclusion' trials.

The 8 adult subjects were assigned to the experimental orders of eight of the children so that in the 'S drawing conclusion' trials each condition/statement variation combination occurred eight times, once in each trial position and in the 'S judging E's conclusion' trials each condition/statement variation combination occurred eight times, once in each two successive trial positions.

As with the children half the adult Ss commenced with the 'S drawing conclusion' trials and half commenced with the 'S judging E's conclusion' trials.

c. Results

'S drawing conclusion' trials

For each condition (i.e. ball/brick represents p or $\sim p$[1]) there were four responses per subject. Since only two types of response occurred i.e. the subjects selected either a card representing q or one representing $\sim q$, it was decided to analyse the data on the basis of individual subject's responses to each condition rather than to determine the frequency of these two responses for the subjects as a whole. An over all analysis of the frequency of the two responses would, in fact, be misleading in this experiment, since it would conceal one noticeable response strategy where the subject consistently selected a card of one colour regardless of whether it represented q or $\sim q$. However, within the four responses per condition that each subject makes, there is some, though not considerable, inconsistency and, therefore, a subject has been allocated to a particular response category if seventy-five per cent (i.e. three of his four responses) fall within that category. The responses for the subjects are given in Table 16.

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1. p refers to the object mentioned in the statement and $\sim p$ to the object not mentioned in the statement. Similarly q refers to the card mentioned in the statement and $\sim q$ to the card not mentioned in the statement.

Table 16

Responses in 'S drawing conclusion' trials

Responses	No. of Ss producing responses	
	Given p	Given $\sim p$
Select q	20 (20)[1]	15 (13)
Select $\sim q$	0	4 (3)
Select one colour consistently	3	3
Other responses [2]	1	2
Total	24	24

Selection of q rather than $\sim q$ to follow p and selection of q rather than $\sim q$ to follow $\sim p$ were significantly above chance level ($p < .001$ and $p < .02$ respectively).

It should perhaps be noted that all four $\sim q$ responses to $\sim p$ were obtained from subjects aged 4 years 7 months and over and the consistent selections of one colour were all obtained from three subjects aged 3 years 6 months and younger.

Adult subjects

Adult subjects consistently made q responses to p and $\sim q$ responses to $\sim p$.

'S judging E's conclusion' trials

There were four responses for each condition and

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1. The number in brackets shows the number of subjects whose responses are consistently within this category i.e. subjects who make this response on all four occasions.
2. Here the subject has selected q on two occasions and $\sim q$ on two occasions.

again there were only two response types i.e. the subject either said the experimenter's conclusion was 'all right' or it was 'wrong'. As with the 'S drawing conclusion' trials an over all frequency analysis of these two response types would conceal one response in which the subject consistently said the experimenter's conclusion was 'all right' (or 'wrong') regardless of whether q or $\sim$q had been selected. Therefore, an analysis based on each subject's responses to each condition has been made again. Subjects have been allocated to a particular response category when at least seventy-five per cent of their responses fall within this category. The responses are given in Table 17.

Table 17

Responses in 'S judging E's conclusions' trials

Responses	No. of Ss producing responses			
	p.q	p.$\sim$q	$\sim$p.q	$\sim$p.$\sim$q
Judge 'all right'	22 (19)[1]	1 (0)	12 (9)	8 (2)
Judge 'wrong'	0	21 (19)	5 (4)	11 (8)
Consistently judge 'all right'/'wrong'	2	2	2	2
Other responses[2]	0	0	5	3
Total	24	24	24	24

1. The number in brackets shows the number of subjects whose responses are consistently within this category i.e. subjects who make this response on all four occasions.
2. Here the subject has judged 'all right' on two occasions and 'wrong' on two occasions.

Judgements of p.q 'all right' and p.~q 'wrong' were significantly above chance level ($p < .001$). There was no significant tendency to judge ~p.q or ~p.~q either 'all right' or 'wrong'.

All five subjects who judged contingency ~p.q 'wrong' were aged over 4 years 2 months and four of these subjects were, in fact, the subjects who produced ~q responses to ~p in the 'S drawing conclusion' trials. Judgements of the ~p.~q contingency also appear to be related to age with six of the eight 'all right' judgements coming from subjects aged 4 years 1 month and over, although 'wrong' judgements were fairly evenly distributed between the younger and older halves of the subjects. Consistent judgements of 'all right' (or 'wrong') regardless of the contingency were obtained from two subjects of 3 years 4 months and younger.

Adult subjects

Adult subjects consistently judged p.q to be 'all right', ~p.q to be 'wrong', p.~q to be 'wrong' and with the exception of one subject, on one occasion only, adult subjects judged ~p.~q to be 'all right'. This one occasion on which an adult judged ~p.~q to be wrong is explainable on the grounds of the subject mishearing the conditional (if there is a brick, then there is a white card' since in his justification he said: 'There should be a white card when it's a ball' and when the experimenter asked him why this should be so, he replied: 'Because you get the red card with the brick'.

Justifications

For both conditions a number of the younger subjects produced justifications such as 'Cos it is', 'Because I want to'. A number of subjects simply reaffirmed their own or the experimenter's response. For example when asked: 'Why is the red/white card supposed to be there?' they replied: 'Because it's a red card' or when asked: 'Why is it 'all right'/'wrong' they replied 'Because it's wrong' or 'Because it's a red card' (when the experimenter had selected a red card). Some subjects consistently referred to the ball or brick (whichever was present) in all their trials. This occurred even when the ball or brick represented p or $\sim p$ and they responded with q and even when the $\sim p.q$ contingency was presented to them and judged to be 'all right'. For example when the conditional was 'If there is a brick, then there is a red card' and a ball was placed in front of the subject he responded with a red card and justified his response by saying 'Because there's a ball'. This suggests that the subject has either never noted the brick referred to in the conditional, or that he has forgotten about the brick by the time he makes his justification, or that he considers it irrelevant when making his response.

As in the previous 'Stars and wee animals' experiment older children (most markedly the four subjects who produced $\sim q$ responses to $\sim p$ and who judge $\sim p.q$ 'wrong' and $\sim p.\sim q$ 'all right') and adults tend to produce justifications including modal expressions. For example from the children: 'The white's all right because if there's a brick then it

must be white. If there's a ball then it must be red', 'If it has a brick it's got to be red. The white one's wrong', 'Cos it's supposed to be red, isn't it', 'Because it has to be a white one. There's supposed to be a white one when you put the ball there and a red one when you put the brick there! The following were obtained from adults. 'It shouldn't be red if the ball's there. It should be the white card'. 'Well, if the red card goes with the brick, I've picked the white card because you've put the ball there, not the brick'.

d. Discussion

The very young children in the 'Stars and wee animals' experiment produced a systematic, but conditional-unrelated, response pattern in the form of an end-to-end search strategy. In this experiment another systematic, but conditional-unrelated response pattern is also produced by the youngest children. This takes the form of selection of the same coloured card, irrespective of the contional in the 'S drawing conclusion' trials and consistent judgements (either all 'all right' or all 'wrong'), irrespective of the conditional, in the 'S judging E's conclusion' trials. Here perhaps we have evidence that the youngest subjects take little, if any, notice of verbal information conveyed in a conditional statement, but that their responses are highly systematic, the exact nature of the response depending on the nature of the task and the constraints it imposes. It should be noted that although not acting in accordance with the conditional,

these subjects are nevertheless acting in accordance with the general nature of the task. They do make responses of the type the task requires.

From Tables 16 and 17 it can be seen that, like subjects in the 'Stars and wee animals' experiment, some subjects indicate the acceptability of q following p but, unlike the subjects in the 'Stars and wee animals' experiment, they also indicate that q can follow $\wedge p$. Perhaps here we have evidence that the rejection of $\wedge p.q$ in the 'Stars and wee animals' experiment (i.e. the 'matching' responses) was a function of the material used and particularly the use of attributes present and absent to represent p, q, $\wedge p$ and $\wedge q$. In this experiment the subject appears to be 'matching' his response or the experimenter's response to the card referred to in the conditional statement. Little notice appears to be taken of the antecedent in the conditional. 'Matching' of response to the card referred to in the conditional could also account for the twelve subjects who judge $\wedge p.q$ to be 'all right' and the eleven subjects who judge $\wedge p.\wedge q$ to be 'wrong'. Seven subjects always selected or accepted q and always rejected or did not accept $\wedge q$ to go with both p and $\wedge p$.

Five subjects, all above the mean age of the group judge $\wedge p.q$ to be wrong and $\wedge p.\wedge q$ to be 'all right' and of these five subjects, four also produce $\wedge q$ responses to $\wedge p$ in the 'S drawing conclusion' trials. These four subjects give justifications including modal expressions and here we have evidence that at the upper end of the age range 'equivalence' responses are operating. However

for the $\sim p.\sim q$ contingency three other subjects also make an 'all right' judgement. Two of these subjects are below the mean age of the group. An examination of the over all response patterns of these three subjects reveals that all three gave q in response to both p and $\sim p$ and all three judged p.q and $\sim p.q$ 'all right' and $p.\sim q$ 'wrong'. Clearly this evidence does not fit any of the three response types put forward so far i.e. it cannot be explained as 1) a systematic, but conditional-unrelated response pattern, 2) a 'matching' response pattern, 3) an 'equivalence' response pattern. In fact the response patterns of these three subjects conform to a truth-functional analysis of implication. Their justifications, however, do not contain modals and tend to reaffirm their own or the experimenter's conclusions or to refer to the ball or brick placed in front of them. In view of the non-truth-functional treatment of implication by adult subjects in this experiment, it would appear highly unlikely that these three children (the youngest only 3 years 7 months) are basing their responses on truth-functional logic, but exactly why this particular response pattern has emerged defies explanation at the moment.[1] [2]

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1. See reference to 'growth errors' in Chapter V. Discussion.
2. Further discussion relevant to this experiment will be found in the discussion of the following experiment and in Chapter V. Discussion.

D. Experiment 6. Boat and Train

a. Introduction

It has been known for a long time that the ability to reason deductively varies according to the nature of the experimental task. Lefford (1946) has demonstrated that the incidence of fallacious reasoning is greater with emotionally toned items than non-emotionally toned items and Wilkins (1928) studying syllogistic reasoning found that valid conclusions occurred more frequently when the subject was familiar with the material than when the material was symbolic or unfamiliar to the subject. Janis and Frick (1943) found that a subject was more likely to reject a valid argument if he disagreed with the conclusion than when he agreed with the conclusion and more likely to accept an invalid argument when he agreed with the conclusion than when he disagreed with the conclusion.

Smedslund (1960) points out that if someone prefers person A to person B and person B to person C then it is assumed by adults that he will also prefer person A to person C. He describes this as an 'example of those peculiar constructs which are somehow inbetween synthetic and analytic, i.e. which have an empirical content, but are felt to be logically necessary'. To examine whether children between five and seven years are capable of making inferences with this type of material he carried out an experiment in which the subject was shown three pictures of a child. On each side of the child was an

object. On the first picture the child was pointing at object A and not at object B. On the second picture the child was pointing at object B and not at object C. On the third picture objects A and C were on either side of the child who pointed at neither object. The subject was told that the child in the pictures was telling them which object he would like to have. After the subject had been shown the first two cards he was asked to select (between objects A and C) the object which the child in the picture preferred. The results indicated an almost complete absence of transitivity with the subjects making selections based on their own preferences or on other irrelevant features of the situation.

In this study so far two experiments on implication have been conducted. In the first experiment, 'Stars and wee animals', the material used appeared to influence the response patterns of many of the subjects in that they tended to 'match' stars with wee animals and no stars with no wee animals irrespective of the conditional statement. In the second experiment, 'Ball, brick and cards' no obvious relationship existed between the material and the majority of subjects appeared to be using the conditional statement as a guide upon which they based their responses. In the next experiment, therefore, it is proposed to replicate the outline of the 'Ball, brick and cards' experiment, but to use material which the child considers to be related, e.g. a train and a railway line, and to use material which the child considers not to be related, e.g. a boat and

a railway line. It is hoped that this procedure will give some indication of how resistant to the child's everyday experience are the response patterns of the 'Ball, brick and cards' experiment.

In the next experiment p and $\sim p$ are represented by a railway line and some water in a blue saucer-shaped container and q and $\sim q$ by a boat and train. Here one would predict that a child, on the basis of his everyday experience of these items, would associate the boat with the water and the train with the railway line.

b. Method

In order to ascertain whether the material used was related for pre-school children a pre-test was carried out with six children who were not experimental subjects, but who were of the same age range as the experimental subjects. Each subject was shown the toy train, the toy boat, the railway line and the blue saucer-shaped container filled with water and described by the experimenter as a train, a boat, a railway line and some water. The subject was asked: 'What goes with the water?' and when he had responded: 'What goes with the railway line?' All subjects linked the boat with the water and the train with the railway line. The subjects were also asked whether the boat could go with the railway line and whether the train could go with the water. All six subjects responded 'No' to these questions.

i) Subjects

24 nursery school children (12 boys, 12 girls) aged

between 3 years 1 month and 4 years 11 months. Mean age 4 years 1½ months, median age 4 years 1½ months.

ii) Material

A toy train, a toy boat, a section of railway line from a toy railway set and a blue saucer-shaped container (diameter 5½") filled with water.

iii) Procedure

'S drawing conclusion' trials

Each S was tested individually seated at a low table. E said to S: 'I've got a train, a boat, a railway line and some water'. E placed the items in front of S and said: 'Show me the train' (boat, railway line, water). After S had pointed to each item E asked: 'What's this?' and pointed to each item in turn. When S had named each item E said: 'We are going to play a game and in this game I'll put the water or the railway line there (E indicated a position on the table in front of S) and you have to put the train or the boat there'(E indicated a second position adjacent to the first position and handed the train and boat to S). Now listen carefully to what I say. If there is a railway line/water, then there is a boat/train'. If S did not place either the boat or the train next to the railway line/water E asked: 'What are you going to put there?' After S had selected either the boat or train E asked: 'Why is the boat/train supposed to be there?' After this E said: 'Now we'll play the game again'. E handed the boat and train to S and the procedure was repeated from the point where E says: 'This time I'm going to put the railwayline/water there'.

'S judging E's conclusion' trials

After the initial identification of objects as in the 'S drawing conclusion' trials E said: 'We are going to play a game and in this game I'll put the water or the railway line there (E indicated a position on the table in front of S) and then I'm going to put the train or the boat there (E indicated a second position adjacent to the first position), but sometimes I'll put the wrong one there and sometimes it will be all right. This time I'm going to put the water/railway line there (E positioned the water/railway line in front of S). Now listen carefully to what I say'. E then presented the conditional statement and said: 'I'm going to put the boat/train there'(E positioned the boat/train next to the water/railway line). E then asked: 'Is the boat/train all right or is it wrong?' When S had responded E asked: 'Why is it all right/wrong?' After this E said: 'Now we'll play the game again' and the procedure was repeated from the point where E says: 'This time I'm going to put the water/railway line there'.

iv) Design

In the 'S drawing conclusion' trials the water/railway line represented p or $\sim p$. This gave two conditions i.e. either an item representing p or one representing $\sim p$ was placed before S. In addition the statement could involve four combinations of water/railway line and train/boat (i.e. Water$\supset$boat, water$\supset$train, railway line$\supset$boat, railway line$\supset$train). Therefore each S was presented

with all four statement variations for each condition. This gave eight trials per S. The two conditions were alternated for each S, with half the Ss commencing with the water/railway line referring to p and half with the water/railway line indicating ~p.

For the twenty-four Ss each condition occurred 96 times, 12 times in each trial position. For the twenty-four Ss each statement variation occurred 48 times, 6 times in each trial position and each condition/statement variation combination occurred 24 times, 3 times in each trial position.

In the 'S judging E's conclusion' trials there were four conditions representing contingencies p.q, p.~q, ~p.q and ~p.~q. Again there were also four statement variations used with each condition giving 16 trials per S. Each S was assigned to one of the 24 orders resulting from permutation of the four conditions.

For the twenty-four Ss each condition occurred 96 times, 6 times in each trial position. For the twenty-four Ss each statement variation occurred 96 times, 6 times in each trial position and each condition/statement variation combination occurred 24 times, at least once and no more than twice in each trial position.

The 'S drawing conclusion' trials were conducted in one session, the 'S judging E's conclusion' trials were conducted in two sessions. Half the subjects commenced with the 'S drawing conclusion' trials and half commenced with the 'S judging E's conclusion' trials.

c. Results

'S drawing conclusion' trials

As in the earlier 'Ball, brick and cards' experiment for each condition (i.e. water/railway line represents p or ~p) there were four responses per subject. Two of these responses occurred where p and q were related (i.e. water and boat, railway line and train) and two responses occurred where p and q were not related (i.e. water and train, railway line and boat). The data have been analysed on the basis of each subject's responses to each condition as in the 'Ball, brick and cards' experiment, but this time a further breakdown of results separates those responses made when p and q were related from responses made when p and q were not related. For each subject this gives two sets of two responses within each condition and a subject has been allocated to a particular response category if both his responses fall within that category. The responses for the subjects are given in Table 18.

Selection of q rather than ~q to follow p and selection of q rather than ~q to follow ~p were significantly above chance level ($p < .001$) when p and q were related and when they were not related.

The three subjects who matched related items regardless of the condition were all aged 3 years 8 months and younger.

'S judging E's conclusion' trials

Again an analysis of the results has been made on the basis of each subject's responses to each condition.

For each condition there were four responses per subject and these have been divided further into the two responses which occurred when p and q were related and the two which occurred when p and q were not related. A subject has been allocated to a particular response category when both his responses fall within that category. The responses are given in Table 19.

Table 18

Responses in 'S drawing conclusion' trials

Response	No. of Ss producing responses			
	Given p		Given ~p	
	R	NR	R	NR
Select q	21 r	20 nr	20 nr	20 r
Select ~q	0 nr	1 r	0 r	0 nr
Consistently match related items [1]	3	3	3	3
Other responses [2]	0	0	1	1
Total	24	24	24	24

R = p and q are related

NR = p and q are not related

r = What is given and the selection are related.

nr = What is given and the selection are not related.

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1. Here three subjects consistently matched the boat to the water and the train to the railway line in all conditions.
2. Here the subject selected q on one occasion and ~q on one occasion.

Table 19

Responses in 'S judging E's conclusion' trials

Response	No. of Ss producing responses							
	p.q		p.~q		~p.q		~p.~q	
	R r	NRnr	Rnr	NR r	Rnr	NR r	R r	NRnr
Judge 'all right'	8	8	0	2	8	8	3	3
Judge 'wrong'	0	0	7	5	0	0	4	5
Consistently judge 'all right'/'wrong'	6	6	6	6	6	6	6	6
Consistently match related items [1]	10	10	10	10	10	10	10	10
Other responses [2]	0	0	1	1	0	0	1	0
Total	24	24	24	24	24	24	24	24

R = p and q are related

NR = p and q are not related

r = the contingency given is related.

nr = the contingency given is not related.

In this test exactly two-thirds of the subjects produced either consistent judgements of 'all right'/'wrong' or consistent judgements in which related items were 'all right' and not related items 'wrong'. This latter response came from children as old as 4 years 11 months. The former judgement came only from children aged 4 years and younger. These two response types accounted for all children up to and including age 4 years 2 months.

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1. Here ten subjects consistently judged related items 'all right' and not related items 'wrong' in all conditions. The items so judged were the ones on the table in front of the subject and not those referred to in the conditional.

2. The contingency was judged 'all right' once and 'wrong' once.

Of the eight remaining subjects all eight judged p.q and $\sim$p.q 'all right' regardless of whether p and q were related and seven of the eight judged p.$\sim$q 'wrong' when the items were not related. With other contingencies the situation was less clear.

Justifications

As in earlier experiments a number of younger children responded 'Cos' and other subjects simply justified by referring to one of the items placed on the table by the experimenter, e.g. 'Because there's a railway line'. They did not respond in this way to items they themselves had selected which suggests that this justification is not just a naming of one item they can see.

A large number of justifications in the 'S judging E's conclusion' trials referred to the relationship between the items. Only two subjects gave this type of justification in the 'S drawing conclusion' trials. Typical examples were 'Because boats always go on water' (p was a railway line, q a boat, $\sim$p was given and the subject responded with q), 'Because trains do go on railways' (p was a railway line, q a boat, a railway line and a train were given and the subject said this was 'all right'), 'Because trains don't go on water' (p was a railway line, q a train, some water and a train were given and the subject said this was 'wrong').

With older subjects who gave q in response to p

and $\sim p$ and judged p.q and $\sim p.q$ 'all right' regardless of the relationship between the items there were a few justifications similar to the justifications given by older subjects in the 'Stars and wee animals' and 'Ball, brick and cards' experiments. Examples were: 'Because it should go there' (p was a railway line, q a train, $\sim p$ was given and the subject responded with q), 'It's got to because it has. It's supposed to be there' (p was some water, q a railway line, p was given and the subject responded with q). However such justifications were less frequent than in the earlier experiments and were markedly less sophisticated.

d. **Discussion**

In this experiment, as in previous experiments, we have evidence of younger children producing systematic, but conditional-unrelated responses. Here it applied only to the 'S judging E's conclusion' trials where six subjects made consistent judgements of 'all right' or 'wrong' irrespective of the conditional. In addition, though, we have another form of consistent response which is conditional_unrelated, which applies throughout the age range, and which can be attributed to the nature of the material used in the experiment. In the 'S drawing conclusion' trials three subjects consistently selected items which were related in their experience rather than in the conditional. In the 'S judging E's conclusion' trials this response was very frequent with ten subjects consistently making their judgements on the basis of the

relationship between the material in front of them rather than on the basis of the conditional.

It is not surprising to find that the nature of the material has influenced some responses, but why it should be more pronounced in one set of trials needs some explanation. One could perhaps argue that to make a judgement of someone else's response is intrinsically more difficult than to make the response oneself. This may or may not be the case, but in the previous 'Ball, brick and cards' experiment there was no such movement from conditional-related (i.e. responses where some account was taken of the conditional) to conditional-unrelated responses between the 'S drawing conclusion' trials and the 'S judging E's conclusion' trials. In that experiment there was no indication of differing degrees of difficulty in the two sets of trials. Perhaps in this experiment the addition of another variable has made the task more complex and, whereas in the 'Ball, brick and cards' experiment the two conditions could both be coped with, even though it was more difficult to judge the experimenter's response than to make a response, in this experiment the additional variable has pushed the complexity of the task in the 'S judging E's conclusion' trials to a point where many children cannot cope with the conditional and so they utilize another strategy. Another explanation could be that in the 'S drawing conclusion' trials the subject only sees one of the items in front of him until he has made his response. In the 'S judging E's conclusion' trials, however, the subject

sees two items, either related or not related, in front of him before he makes his judgement. Perhaps actually seeing the items in proximity is sufficient for their relationship or lack of relationship, in his experience, to become dominant over the conditional.

As in the 'Ball, brick and card' experiment there was a tendency to select q in response to p and $\sim$p and to judge p.q and $\sim$p.q 'all right' and p.$\sim$q and $\sim$p.$\sim$q 'wrong'. Four subjects consistently responded in this manner. These subjects were aged 4 years 4 months and over.

Unlike earlier experiments no subject consistently produced 'equivalence' responses although one subject, aged 4 years 11 months, produced a response pattern found in the 'Ball, brick and cards' experiment[1] where q was given in response to p and $\sim$p and p.q, $\sim$p.q and $\sim$p.$\sim$q were judged 'all right' and p.$\sim$q was judged 'wrong', i.e. a truth-functional analysis of implication.

The main difference between the results of this experiment and the earlier 'Ball, brick and cards' experiment seems to be in the direction of what appears to be a lower level of performance. In both experiments there are conditional-unrelated responses, but in this experiment such responses are more pronounced and take two forms i.e. systematic judgements of 'all right'/'wrong'[2] and matching of related items.

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1. This response pattern is also described on p. 172.
2. In the 'S drawing conclusion' trials no systematic strategy comparable with consistently selecting one colour was employed.

What appears to be a matching of the consequent in the conditional and ignoring the antecedent is also found in both experiments. It is very marked in the 'S draws conclusion' trials. However, consistent use of this strategy is restricted to older subjects whereas in the 'Ball, brick and cards' experiment it was replaced, in older subjects, by an 'equivalence' response pattern.

A further point relates to justifications. In this experiment they were noticeably more difficult to obtain, they were shorter and rarely did the child attempt to relate the conditional statement to the material in front of him in any detailed way.[1] It should also be noted here that justifications containing such expressions as 'it should', 'it's got to', which are similar to justifications obtained from subjects who produced 'equivalence' responses in earlier experiments, were obtained on one or two occasions from older children, in this experiment, in situations, for example, where they gave q in response to $\wedge p$ or judged $\wedge p.q$ 'all right'. Such justifications were very infrequent, they covered only a limited range of expressions (no child, for example, used the word 'must') and did not form part of fairly detailed justifications as in earlier experiments, but the fact that they did occur means that one cannot equate them with 'equivalence' responses as earlier results had suggested.

From the 'Ball, brick and cards' experiment and the

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1. Justifications of the type given on p. 169 were not obtained.

'Boat and train' experiment it is suggested that the following developmental sequence may be operating:

1. Conditional-unrelated responses

a) The first stage produces responses in which the subject treats the task in a systematic way, but this bears no relation to the conditional. He is nevertheless acting within the constraints of the task and producing the type of response required.

In the 'Ball, brick and cards' experiment this takes the form of systematically responding with a card of one colour or systematically responding 'all right'/'wrong'. In the 'Boat and Train' experiment this would take the form of systematically selecting one item (i.e. either the boat or the train)[1] or systematically responding 'all right'/'wrong'.

b) The second stage can only be demonstrated in the 'Boat and train' experiment. Here another variable enters the task and the subject responds on the basis of this variable. It is argued that this is a slightly more advanced stage than stage a) because i) this response came from subjects throughout the age range whereas response a) was restricted to the very youngest subjects and ii) it requires the subject to make a different response on each trial i.e. he has to assess the task on each trial (in the 'Boat and train' experiment he had to assess the relationship between items) whereas in stage a), after the first response, he simply repeats

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1. This response did not occur.

whatever he has done before.

In the 'Boat and train' experiment this takes the form of selecting a boat whenever there is water, a train whenever there is a railway line and judging related items 'all right' and unrelated items 'wrong'.

2. Part-conditional responses

a) The first stage involves responding to only part of the conditional. In these experiments it was the consequent. The antecedent appears ignored.

In both experiments this took the form of selecting whichever item was represented by q in the conditional irrespective of whether p or $\sim$p was placed in front of the subject. It also took the form of judging 'all right' any pair of items in which the item represented by q appeared and judging 'wrong' any pair of items in which the item represented by q did not appear irrespective of whether p or $\sim$p was also in front of the subject.

b) This stage is more tenuously suggested, but it may be that the few subjects who produced what appeared to be truth-functional treatments of implication are at a stage where they are able to produce 'equivalence' responses for some conditions, but are still in stage a) for other conditions. Alternatively they do note the antecedent as well as the consequent in all conditions, but the consequent is dominant. In this case their 'logic' takes the form of selecting whatever the consequent represents or judging 'all right' a contingency where whatever the consequent represents appears. However, if whatever the consequent represents does not appear an

'equivalence' type process operates.

It is suggested that this stage may fit in here because it came from younger subjects than the 'equivalence' responses in the 'Ball, brick and card' experiment and came from the oldest subject in the 'Boat and train' experiment where no 'equivalence' response patterns were found.

3. Equivalence responses

This stage was only found in the 'Ball, brick and cards' experiment and only with older subjects. It involved giving q in response to p, $\sim$q in response to $\sim$p and judging p.q and $\sim$p.$\sim$q 'all right' and p.$\sim$q and $\sim$p.q 'wrong'. These are the responses given by adults.[1]

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1. Further discussion of a general developmental sequence and discussion of points raised in this chapter will be found in Chapter V.

CHAPTER IV

VERBAL INFERENCES

A. Introduction to Verbal Inferences

It is the usual practice when conducting experiments with young children to have a task in which concrete material is present either for the children to look at or for them to manipulate. Donaldson and Wales (1969b) refer to this as 'concrete support'. It has been argued that this 'support' is needed because young children are incapable of reasoning at a purely verbal level.

Inhelder and Piaget (1958), in discussing children older than the ones in this study, say: 'It is often sufficient to translate a concrete operation into simple propositions and deny the subject the use of manipulatable objects for working out the operation in question for the problem to become insoluble before the formal level'. In describing the acquisition of conservation Piaget (1962) also says: 'The ability to pass from one point to another and be able to come back to the point of departure, to manipulate the reversible operations, appears around seven to eight years of age. It is limited when compared with the operations of the superior level only in the sense that they are concrete. That is to say, the child can manipulate the operations only when he manipulates the object concretely'.

The use of concrete material in experiments with young children has certain obvious advantages. It provides

a focus for the child's attention and affords assessment of responses on the basis of actions upon the material thus avoiding the difficulties of eliciting and interpreting verbal responses but the situation is far from clear. Different types of concrete material can produce different results in tasks which are otherwise identical. This has been shown in the 'Ball, brick and cards' experiment and the 'Boat and train' experiment in this study. It has also been found that 'concrete support' can sometimes appear to hinder performance. Wohlwill (cited in Donaldson and Wales, 1969) found that children aged between five and seven were more successful with a class inclusion task when the task was completely verbal than when pictures were used.

As far as pre-school children are concerned it is important to know, not only what differing effects different types of material produce but also, whether there are any situations in which they can operate at a purely verbal level.

B. Experiment 7. Apple and Orange

a. Introduction

One of the main features of the concrete operational stage of development is the acquisition of two forms of reversibility, i.e. reciprocity and inversion. Piaget (1962) describes reciprocity thus: 'Reciprocity arises in connexion with relations. If A equals B, by reciprocity B equals A. If A is smaller than B, by reciprocity B is larger than A.' It is this second example of reciprocity, given by Piaget, which has been taken as the basis of an experiment in which no concrete material is used and the children are required to respond verbally to verbally given information.

b. Method

In this task the subject is told that the experimenter has an apple and an orange and that the apple is bigger or wee-er than the orange or that the orange is bigger or wee-er than the apple. He is then, through two types of questions, required to indicate what he considers is the complementary relationship of these two objects, i.e. to indicate an awareness of the logically equivalent combination of the two objects.

The statements used and the questions asked were:

1. I have an apple and an orange. The apple is bigger than the orange. Is the orange bigger or wee-er than the apple?
2. I have an apple and an orange. The apple is bigger

than the orange. Is the orange wee-er or bigger than the apple?

3. I have an apple and an orange. The apple is wee-er than the orange. Is the orange bigger or wee-er than the apple?
4. I have an apple and an orange. The apple is wee-er than the orange. Is the orange wee-er or bigger than the apple?
5. I have an apple and an orange. The apple is bigger than the orange. Which is wee-er?
6. I have an apple and an orange. The apple is wee-er than the orange. Which is bigger?[1]

i) Subjects

24 nursery school children (12 boys, 12 girls) aged between 3 years 2 months and 4 years 11 months. Mean age 4 years 1 month, median age 4 years ½ month.

ii) Procedure

Each S was tested individually seated at a low table facing E. E said to S: 'Listen carefully. I've got an apple and an orange. The apple is bigger than the orange. Is the orange bigger or wee-er than the apple?' When S had responded E asked: 'Why do you think the orange is wee-er/bigger than the apple?' Where the question was in the form: 'Which is bigger/wee-er?' E asked: 'Why do you think the orange/apple is bigger/wee-er?' After S had replied E moved on to the next

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1. The apple and the orange appeared equally as first and second mentioned items.

trial commencing with: 'This time I've got another apple and orange'.[1] [2]

iii) Design

For each of the 24 Ss there were 6 trials, each trial covering one of the conditions given on page 193. In each S's six trials there were three trials in which the apple was larger than the orange and three in which it was smaller than the orange. 24 orders were produced by permutation of the first four conditions i.e. the conditions in which the question was of the form: 'Is the orange bigger or wee-er than the apple?' Each S was assigned to one of these orders which covered trials 2 to 5. The first and last trials for each S were conditions 5 and 6 i.e. the conditions in which the question was of the form: 'Which is bigger/wee-er?' These two conditions occurred equally as first and last trials.

c. Results

Out of the twenty-four subjects seventeen gave correct responses to each of the six conditions. Three subjects made one error (one in Condition 4 and two in Condition 1), three subjects made two errors and one

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1. This is a typical trial. Other conditions (i.e. statements and questions) from the list given above were also used to commence a series of trials.
2. A number of possible ways of introducing this task to the subject, such as saying it was a pretend game, were considered in a pilot study, but it was found that commencing the task immediately in the manner described in the Procedure seemed acceptable to the subjects.

subject employed a strategy in which he gave the first-mentioned item in the statement when he was required to name an item and gave the relationship mentioned in the statement (i.e. either bigger or wee-er) whenever he was required to respond bigger/wee-er. Apart from this one subject there was no noticeable error patter. No child aged 4 years 0 months and over made an error.

Justifications

Apart from the usual 'Cos' and 'Because it is' responses there were some justifications which referred to qualities of apples and oranges. For example: 'Because it (the orange) has skin, but bigger skin', 'Because it (the orange) won't take a long time to peel'. A frequent justification was a reaffirmation of the subject's response. For example having replied 'bigger' the subject justified with 'Because it's bigger' or having replied 'apple' the subject said: 'Because it's an apple'. A number of justifications correctly included one relational expression and one or both objects. For example having been told the orange was bigger than the apple and asked: 'Which is wee-er?' the subject responded 'The apple, because the apple is wee-er than the orange'. Another subject having responded 'bigger' (the orange was bigger than the apple) justified with 'Because it is. The apple is wee-er'.

Two subjects (one aged 4 years 2 months and one aged 4 years 11 months) included both items and both relational expressions in their justifications. From the younger subject came: 'the orange is wee-er and the apple is

bigger'. From the older subject came: 'The apple is bigger than the orange and the orange is bigger than the apple'.

d. Discussion

The results of this experiment suggest two things. Firstly that in some circumstances pre-school children can operate very efficiently at a purely verbal level and secondly they can make inferences (as defined in the Introduction to this study. p. 10) at this level. Moreover it is also suggested that they have demonstrated one of the reversible operations denied them by Piaget until the concrete-operational level i.e. reciprocity.

It may be argued that these children are not really reasoning at the level required to handle reversible operations, that they are operating at a lower level and producing responses which superficially resemble those of reciprocity, but what this lower level is and what form the strategy or 'logic' involved takes is difficult to say.[1] One explanation could be that the subjects place an 'absolute' interpretation upon the information they are given. For example if told 'The apple is bigger than the orange' they interpret this as 'The apple is the big one. The orange is the wee one'. When asked: 'Is the orange bigger or wee-er than the apple?' or 'Which is wee-er?' they interpret the question as 'Is the orange big or wee?' or 'Which is the wee one?' and

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1. 'Growth' errors will be discussed in Chapter V. Discussion.

respond accordingly without any awareness of the relational aspect of the situation. This may have happened with some subjects, but it is difficult to extend such an explanation to subjects who justified their responses in such ways as: 'The apple is wee-er than the orange' or 'The apple is bigger than the orange and the orange is wee-er than the apple'.

It should be noted, though, that Clark (1969) argues that linguistic processes are fundamental to deductive reasoning of this type and that with adults the 'deep structure' underlying statements such as 'A is better than B' takes the form 'A is good, B is good'. Added to this is the 'deep structure' interpretation which attributes more 'goodness' to A than 'goodness' to B. It would appear reasonable to assume that children also have this type of 'deep structure', i.e. 'the apple is big, the orange is big', rather than 'the apple is big, the orange is wee' for 'the apple is bigger than the orange' and, therefore, to argue that children in this study have indeed demonstrated deductive reasoning of the type produced by adults.

Two further points in Clark's theory are relevant to this study. Firstly 'certain "positive" adjectives, like long, are stored in memory in a less complex and more accessible form than their opposites, like short' and secondly 'Listeners can only retrieve from memory, information which is congruent at a deep level to the information they are searching for'. If the information is not 'congruent' then time-consuming adjustments of

information have to be made. Clark has shown that it takes longer to draw conclusions from statements such as 'B is worse than A' than from statements such as 'A is better than B'. It also takes longer to answer the question 'Who is worst?' than the question 'Who is best?' for statement 'A is better than B' (i.e. it takes less time in a 'congruent' situation). In the present study half the trials used the 'positive' adjective 'bigger', but half used the more time consuming (and more complex) opposite form 'wee-er'. In addition the response required of the subject was not 'congruent' with the premiss (i.e. at a deep level the information stored and that sought were not 'congruent').[1]

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1. Further discussion relevant to this experiment will be found in Chapter V. Discussion.

CHAPTER V

DISCUSSION

One of the interesting features of the results of this study has been the almost complete absence of random responses. There has been no random responding in the sense of operating outside the constraints of the task.[1] All subjects adhered to the confines of a formal experimental situation i.e. they responded to a situation which they themselves had not initiated[2] and moreover all subjects responded appropriately within the limits of the task, the nature of which was conveyed to the child by verbally presented information. Where, for example, the nature of the task required the subject to select a box or to make a verbal judgement he made a response appropriate to this requirement. One can, therefore, claim that all subjects adhered to some of the verbally presented information in the task, although not all subjects adhered to the information contained within the premiss associated with the task. Random responses within the constraints of the task did occur (or at least responses which the experimenter could not classify occurred), but these were rare. The over all impression is one of fairly strict adherence to one particular strategy from each subject.

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1. The constraints of the task being those verbal and nonverbal requirements which the task imposes upon the subject.
2. Reference is made to formal and spontaneous situations in Chapter I. Introduction. p. 15.

If one considers the strategies which subjects have employed throughout this study a three-stage developmental sequence, which I propose to describe below, is suggested. It is possible that this sequence has a fairly wide applicability to situations where the child has to handle a verbal premiss relating to physically present material and possibly also to situations where the task is completely verbal i.e. no physical material is present, although with only one such experiment in this study it is impossible to support such a hypothesis.

Stage 1. Premiss-unrelated response

This response, obtained from the youngest children in the study, is completely independent of the information contained within the premiss, yet it is highly consistent and systematic and falls within the constraints of the task. At the lowest level this takes the form of repetition of the same response irrespective of changes in the material displayed before the child and irrespective of differing premisses. It can also take the form of a repeated systematic 'search strategy' if such a response is appropriate to the nature of the task. For example in the 'Ball, brick and cards' and 'Boat and train' experiments this response was exemplified in repeated selection of the same coloured card or repeated judgements of 'all right' (or 'wrong'). In the 'Stars and wee animals' experiment it took the form of a systematic 'end-to-end' search strategy. This 'end-to-end' search strategy was also found in the control conditions in the 'Houses and

boxes' experiment where no premiss was given and the children were simply told that the house was in one of the boxes. This result from control subjects supports the argument that such responses are premiss-unrelated.

Two aspects of these systematic responses are of interest. Firstly in the one condition where adults might have responded systematically i.e. the control condition of the 'Houses and boxes' experiment, they did not do so, and apart from a tendency not to select the 'reward' box of the previous trial [1] no systematic strategy was noted.[2] If this tendency to order and systematic responding applied only to children it leads one to speculate on the possibility of some inborn systematic system. On the other hand both adults and children may be searching for the rule which governs the situation and whereas the children will settle for a simple repetitive rule, i.e. open each box in turn or give the same response, adults expect to find some other rule applying and their responses, apparently random, are partly hypothesis testing (one hypothesis in the 'Houses and boxes' experiment being that a 'reward' box on one trial would not be the 'reward' box on the following trial).

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1. This is referred to on page 99.
2. It should also be noted that other strategies such as preference for the left-most box, frequent adjacent responses and preference for the red box were noted in children in the 'Houses and boxes' experiment and that these, although secondary to the premiss in experimental trials, could become dominant in other situations.

Allied to this, as far as the children are concerned, is the idea, put forward by Legrenzi in a different context (referred to on page 158), of reducing the difficulty of the task and the ways in which children responded may well represent an attempt to simplify the task(this should not be taken to mean that they are capable of a higher level of responding).

The second interesting feature of systematic responses relates only to the 'end-to-end' seach strategies and that these were mainly in the direction of left to right. In addition in the 'Houses and boxes' experiment there was a marked preference for selecting the left-most box with experimental subjects. Had this been with older subjects one could have easily related it to reading habits, but its presence in children, the majority of whom cannot yet read, is surprising and again leads one to speculate upon some 'natural' predisposition to respond in this way.

A second form of premiss-unrelated response also occurs and it is probably later appearing than the response mentioned so far in this stage. In this response qualities of the material used are taken into account. Relationships between the material or perceptually dominant features of the material are used in the response strategies. Not all the experiments carried out in this study lend themselves to a distinction between this and the earlier response, but in the 'Boat and train' experiment it can be clearly seen in responses where the subject has linked

a boat with water and a train with a railway line irrespective of the premiss. In the 'Stars and wee animals' experiment the 'four box selections' where the subject selected first the boxes with stars or wee animals and then the boxes without stars or without wee animals[1] and possibly some of the selections of boxes with stars/wee animals only (i,e, in which the subject did not select boxes with no star or no wee animal) may have reflected this response strategy although the relative infrequency of this type of response in the control group suggests that it is not sufficient to explain all such experimental group responses. It was however the possibility of this having happened and the possibility of subjects having assumed that the presence of one distinctive attribute of the material was linked with another distinctive attribute (i.e. stars being linked with wee animals) that indicated the need for a task of a different nature in the 'Ball, brick and cards' experiment.

It is proposed that this stage of premiss-unrelated behaviour, which falls within the constraints of the task, can also be found when no material is physically present. In this case it takes the form of either repeating some part of the premiss or repeating some part of the question. For example the subject might respond by repeatedly giving whatever is first mentioned in the premiss (or whatever

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1. And the 'four box selections' where no star/wee animal preceded star/wee animal.

is last mentioned) or he might similarly do this with the question he is asked. In making some reference to the premiss in this way it does not mean that his behaviour is guided by the premiss, i.e. there is no understanding or interpretation on his part, but simply a repetition, although this again is guided by the constraints of the task, it is task appropriate, and therefore cannot be considered a simple mechanical repetition. However, there is evidence from only one child in this study to support this proposal. In the 'Apple and orange' experiment this subject always gave the first item referred to in the premiss when he was required to give an item, and referred to the relationship in the premiss when he was required to respond 'bigger' or 'wee-er'. One might also expect to find repetitive answers akin to the 'all right' /'wrong' or repeated reference to the same mentioned item although such responses, in the purely verbal experiment in this study, did not occur. However any hypothesis about Stage 1 responses in purely verbal situations can only be highly speculative. It is interesting to note that the repetition of part of the premiss or question (i.e. first-mentioned or last-mentioned) did not occur in experiments other than the purely verbal one. It may be as Donaldson and Lloyd (1971) suggest that in a statement/physical material situation it is the physical material which is dominant over the statement.[1]

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1. This is discussed below.

Stage 2. Part premiss-related response

In this stage the subject is guided by the information within the premiss, but he does not utilize all the information available within it. Donaldson and Lloyd (1971) suggest that what happens when a child is required to relate statements to physically present objects (or pictures of objects) is that the child is governed by the perceptual properties of the physical array (these properties influence the nature of the child's looking, the things he attends to, the way in which he structures or interprets what he sees) and by his interpretation of the statement. They propose that: 'typically, the child's interpretation is less constrained than that of the adult by the syntactic structure of the utterance. He derives from the language a general notion of the theme: of the elements involved and the kinds of relation that are referred to; but linguistic considerations alone leave open to him certain options which the adult analysis would disallow'. They then go on to suggest that: 'in the absence of a decisive structuring of the language, it is then the structuring of the physical array that determines the outcome'.[1 2 3]

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1. On the basis of this proposal it may be necessary to suggest that children giving Stage 1 responses do not completely ignore the premiss, but that they fail to put an interpretation upon it or put an interpretation upon it which gives way to the properties of the physical

(Continued on p.207).

(Footnote continued from p. 206).

array. It should be noted, though, that there are other aspects of the task apart from the statement and physical array which can be instrumental in directing a response, for example, that the response should be verbal or that it should be a judgement of someone else's behaviour.

2. It should be noted that the Donaldson and Lloyd proposal is referring to situations where the child is answering questions or making judgements about the statement and physical array. This is not always the case in this study since in most of the experiments the child is required to act upon the physical material in order to bring it into line with the premiss.

3. This account of how children relate linguistic utterances to their referents is made with reference to one of a series of experiments conducted at the Edinburgh Cognition Project. In this experiment nursery school children aged between 3 years 7 months and 5 years 0 months were required to judge whether statements containing quantifiers and emitted by a 'talking panda' were true or false in relation to a physical array displayed before them. In some of the conditions, from a few of the youngest subjects, came sequences of 'true' judgements consistent with Stage 1 as proposed in this study, although these were not successive responses since trials for other conditions, to which different responses were given, were interspersed with many one condition.

Certainly the idea that children's interpretations of verbal statements are less governed by syntactic structures than adults' interpretations is very relevant in this study. It can explain the errors with premisses containing negatives. For example in the 'Houses and boxes' experiment and the 'Disjunctive syllogism' experiment a statement such as: 'The house is not in the red box' could have been interpreted as: 'The house is in the red box'. Similarly in the 'Stars and wee animals' experiment premisses including 'no star' or 'no wee animal' could have been interpreted as if the negatives were not there. Where a double negative occurred (for example: 'If there is no star then there is no wee animal') some subjects responded as though a single negative had occurred, e.g. they selected the unstarred box as the one which should contain the wee animal. Presumably here the interpretation extended to include one negative or an awareness of negation but not to the adult encoding of a double negative.

Turning to the physical array side of the situation, and the way it can dominate the statement, one suspects that this may have happened for some subjects in the 'Stars and wee animals' experiment. The presence of stars or wee animals on or in some boxes may have dominated some responses so that starred boxes or boxes containing wee animals were selected. This may have occurred when the subject's interpretation of the premiss contained an awareness of a negative. In the 'Houses and boxes' experiment there was little evidence of the physical array dominating

the premiss although it may have played a secondary role in eliciting certain colour and position preferences which were noted, but which did not extend the child's response beyond the limits of the premiss.[1]

With the 'Ball, brick and cards' experiment and the 'Boat and train' experiment a frequent response was the selection of q irrespective of whether p or ~p was given and the judgements p.q, ~p.q 'all right' and p.~q, ~p.~q 'wrong'. Here the subject consistently makes his response on the basis of the latter half of the premiss. Why this should be so is difficult to say. In this situation there are no obvious features of the physical array which might be governing the response. If one speculates perhaps it is the presence of 'If' before the first half of the premiss which weakens its impact when compared with the second half of the premiss so that: 'If there is a ball then there is a red card' is interpreted by the child as: 'There is a red card'. Or perhaps it is simply a question of the last-mentioned being better retained. A possible alternative explanation is that the nature of the task is dominating the premiss in the way that the physical material might dominate the premiss. The subject knows that he has to make a selection or judge the experimenter's selection and therefore this part of the task takes on the

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1. Here reference is only being made to the influence of physical material when there has also been some indication of the premiss also having influenced the response.

dominant role. In interpreting the premiss he does so in relation to the selection which concerns q (i.e. the red card, the white card; the boat, the train) and p (i.e. the ball, the brick; some water, a railway line) is either not noted or interpreted in a way which classes it as irrelevant or secondary.

In a purely verbal task one can hypothesize that this stage will also be found and will be exemplified by a limited interpretation of the premiss and possibly by the dominance of some aspects of the nature of the task.

Stage 3. Premiss-related response (adult response)

In this stage children produce responses where the information contained within the premiss is used in the way in which adults would use it. This raises the question of whether pre-school children in this study have demonstrated their ability to make inferences as defined in the Introduction to this study (p. 10). The writer argues that in some conditions some of the children have indeed demonstrated this ability. In two of the experiments on disjunction ('Houses and boxes' and 'Disjunctive syllogism') there is evidence that pre-school children can draw a conclusion which follows necessarily from, but is not explicitly contained within, information given to them. Similarly in the seventh experiment ('Apple and orange') this ability is demonstrated and this time at a purely verbal level. In two of the experiments on implication ('Stars and wee animals', 'Ball, brick and

cards') some of the older subjects handled implication as though it were material equivalence and so did adult subjects performing the same tasks. If one accepts only a truth-functional analysis of implication as indicative of inferential behaviour then neither children nor adults makes inferences in response to implication tasks. However, if one accepts the adult responses as the 'standard' against which the children's responses are measured then perhaps one can claim further evidence of inferential behaviour.

The responses from the older children and adults in the implication tasks raise the whole problem of how one assesses reasoning. There is now a growing body of evidence [1] that adults frequently do not reason according to formal logic and that it is becoming more and more unrealistic to judge an individual's reasoning ability against a 'standard' of formal logic. But what do we put in its place? Is there a form of 'psychological' reasoning which is completely independent of formal logic and which may or may not be governed by rules or laws of its own? Or is it as Henle (1971) suggests a matter of determining how the subject interprets the information he is given because thereafter 'evidence for fallacies is essentially lacking'? Henle's argument is that we reason perfectly validly according to formal logic if we take into account all the information (which may be

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1. Reference to this is made in Chapter I. Introduction. (p. 54) and Chapter III. Implication (p. 119).

greater or less than that in the premisses given) used in drawing a conclusion. On this basis handling implication as equivalence is valid if the subject understands 'if p then q' to mean 'if and only if p then q'. Clearly these are questions which cannot yet be answered and in this study it is perhaps better just to say that some pre-school children produced responses which appear identical to adult responses.[1]

One point which should be considered here is the question of 'growth' errors. A number of experimentalists have noted that 'correct' responses obtained from young children are at a later age replaced by 'incorrect' responses. Ervin (1964) found that children who had used correct forms of irregular past tenses later used incorrect forms. For example 'did' and 'came' became 'does' and 'comed'. Lunzer (1965) carried out a task in which he studied children's understanding of areas and perimeters. He observed that children around the age of eight to ten would judge a rectangle measuring 5" x 45" to be equal in area to one measuring 25" x 25". Younger children, given the same task, correctly judged the areas to be unequal. Bruner (1966) found that, when asked to predict the level of liquid when it was poured from one glass to another of the same diameter, but different height, sixty per cent of four-year-olds were correct, but only twenty to thirty

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1. If one takes Henle's argument further then perhaps children who produced Stage 2 responses (and even Stage 1 responses) can be said to have reasoned validly.

per cent of five to seven-year-olds were correct. Other such examples exist, but these are typical of the kinds of results found. The proposed explanations for this phenomenon suggest that older children are applying different rules and considering a wider range of available information (some of which can be irrelevant to the task) than the younger children. Whether one can then go on to argue that the correct responses of younger children and adults are of a different order, that they are fundamentally different, is not clear. Certainly observations, that developmentally children who respond correctly then proceed to respond incorrectly, are inadequate for any such conclusion to be drawn, since it is just as possible that the young children and adults are operating identically and it is the older children who are 'regressing'. Whatever the explanation for this kind of finding, one has to allow for the possibility of children who have produced results, apparently the same as those of adults, failing to produce these responses at a later age.

The three stages outlined above reflect a movement towards the constraints of linguistic utterances from which can be drawn inferences. One can say that the linguistic ability, i.e. the ability to interpret the utterance, must be present for the inference to occur, but it is less clear whether the inference follows from the linguistic interpretation as part of the interpretation or whether it is a separate step which does not always occur.

In some tasks more children appeared to be operating at Stage 3 than in other tasks. For example in the 'Apple and orange' experiment seventeen subjects attained this level whereas in the 'Boat and train' experiment no child did. Does one then infer that it is the nature of the task, the material used and the linguistic complexity of the premiss which is concealing the inferential ability of the children in the 'Boat and train' experiment or is there something fundamentally different in the type of inference required in the two tasks? This question is, of course, impossible to answer at present, but whatever the answer we know that the same question can be put in relation to adult reasoning where different types of task also elicit different types of response.

In this study an attempt has been made to simplify the task, to reduce the confounding variables (discussed in the Introduction. p. 3). Clearly many such variables have still impinged upon the experiments. It is impossible to conduct an experiment in a psychological and physical vacuum, but some evidence of inferential behaviour has been obtained from some children. It may be that if one could iron out more confounding variables more evidence of inferential behaviour would be obtained and as Mehler and Bever (1968) say: 'Although we may draw conclusions about abilities from the child's successful performance, we cannot infer the child's underlying incompetence from his failure to perform'.

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